9320-1305

2FRA / 2FRAM TWO PEN RECORDER

includes MODEL 2FR

OPERATING AND SERVICE MANUAL

HEWLETT PACKARD hp MOSELEY DIVISION

WARRANTY

All our Instruments are warranted to be free from defects in material and workmanship for a period of one year after delivery to the original purchaser. Liability under this warranty is limited to servicing, adjusting, or the replacement of the defective parts (other tubes, fuses, or batteries) on any instrument returned for this purpose, transportation charges prepaid.

For assistance of any kind, including help with instruments under warranty, contact your nearest Hewlett-Packard field office for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, except transportation charges. Estimates of charges on non-warranty or other service work will always be supplied, if required, before work begins.

OPERATING AND SERVICE MANUAL

for

MODEL 2FRA & 2FRAM
TWO PEN RECORDER
(including MODEL 2FR)

by

HEWLETT PACKARD hp MOSELEY DIVISION

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Pasadena, California

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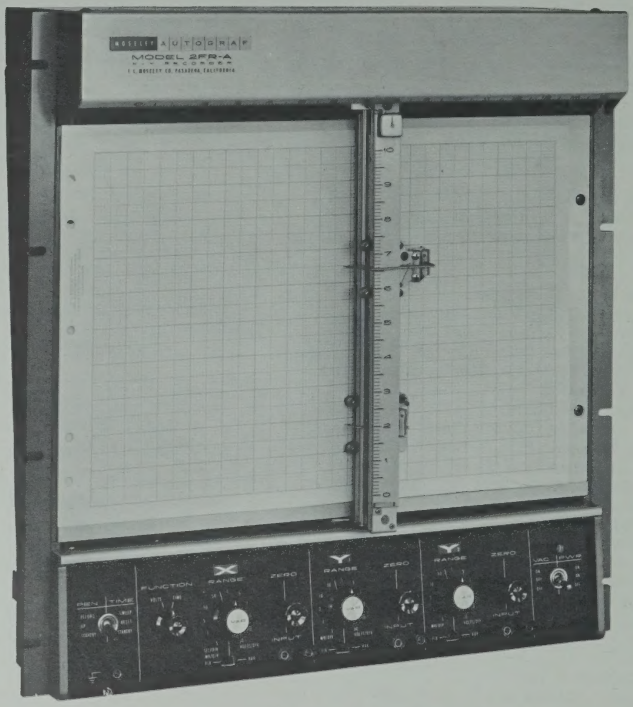


FIGURE 1-1. MODEL 2FRA TWO-PEN RECORDER

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION

1-2. PURPOSE AND CAPABILITY. The Moseley Models 2FRA and 2FRAM are two-pen, three axis graphic recorders designed to plot two cartesian coordinate curves simultaneously from DC signals representing a single independent variable and two dependent variables. The two pens move vertically on a single carriage which travels horizontally. Each pen has full scale plotting range in both X and Y directions with less than 0.1 inch horizontal separation. The AUTOGRIP electric platen accepts standard graph paper with 10" x 15" (25 cm x 38 cm) recording area or smaller. A built-in sweep generator provides a time base on the horizontal axis for plotting two dependent variables against time. Each axis is controlled by an electrically independent servo mechanism with one megohm input resistance on eleven fixed ranges. Variable range control is provided to accommodate arbitrary voltage situations.

1-3. MANUAL COVERAGE. This manual applies to Models 2FRA and 2FRAM beginning with Serial No. 79, and Model 2FR, Serial No. 1 through 78. Models 2FR and 2FRA are scaled and calibrated in inches; Model 2FRAM is scaled and calibrated in centimeters. Section VI covers differences in specifications, operation and maintenance of early production Model 2FR.

1-4. SPECIFICATIONS

RECORDING MECHANISM: Three independent servo-actuated drives, one for each axis, X, Y, and Y_2. All three systems are isolated and free of ground.

RECORDING PLATEN: AUTOGRIP electric paper holddown grips any dimension paper up to 11" x 17" (28 x 43 cm).

DC INPUT RANGES: Standard Unit: Eleven calibrated ranges for each axis: 0.5, 1.0, 5, 10, 50 millivolts/division (inch) and 0.1, 0.5, 1, 5, 10, 50 volts/division (inch).

Metric Unit: Eleven calibrated ranges for each axis: 0.2, 0.5, 2, 5, 20, 50 millivolts/centimeter and 0.2, 0.5, 2, 5, 20 volts/centimeter.

Both models have potentiometric input available on each axis for operation with essentially zero current drain on the four lowest ranges. A stepless range control feature permits arbitrary full scale voltage settings on any range up to the maximum limits of the instrument (500 volts on Y_1, Y_2 axes; 750 volts on X axis).

TIME BASE INTERVALS: Standard Unit: Five calibrated sweeps of 0.5, 1, 5, 10, and 50 seconds/division (inch) on X axis only.

Metric Unit: Five calibrated sweeps of 0.2, 0.5, 2, 5, and 20 seconds/centimeter.

Basic sweep ranges provide 7.5, 15, 75, 150 and 750 seconds for full scale traversal.

INPUT RESISTANCE: One megohm at null on all fixed ranges. In variable range mode, 100,000 ohms on four most sensitive steps and one megohm on remaining steps.

RECORDING SPEED: Maximum speed on both Y axes is 20 inches/second (50 cm/sec): on X axis, 10 inches/second (25 cm/sec).

STANDARDIZATION: Continuous electronic reference, zener diode controlled.

ACCURACY: Better than 0.2% of full scale with resettability better than 0.1% of full scale. Time base accuracy better than 5% of full scale, adjustable to 1%.

POWER REQUIREMENTS: 115/230 volts, 50/60 cps, approximately 200 volt/amperes. Slide switch determines voltage acceptance.

PHYSICAL DIMENSIONS: Overall: 19-7/32" high, 19" wide, 8" deep. Inside rack clearance; 17-3/4" wide, 5-5/8" maximum depth. (See Figure 1-2.)

1-5. ACCESSORY EQUIPMENT

1-6. While the Model 2FRA two-pen X-Y recorder has many direct uses, its utilization may be increased by the addition of accessory equipment available for specialized applications. Because of the rack mounting design, this model will not accept roll chart accessories. Curve followers, line followers, and character printers also are not available for use with these instruments due to the dual pen carriage beam.

1-7. LOGARITHMIC CONVERTER. Moseley Model 60D Logarithmic Converter accepts either AC or DC input voltages and delivers an output DC voltage proportional to the logarithm of the positive peak amplitude of the input voltage. This converts the recorder input on one axis from linear to logarithmic (db) scale, permitting direct plotting on semi-log paper. Log-log plotting may be accomplished using a converter in each axis. Since the logarithmic scale compresses the higher amplitudes and expands the lower ones, wide ranges in level with maximum accuracy at low amplitudes may be obtained. The Model 60DM converter is available for use with the metrically scaled Model 2FRAM.

1-8. TYPE 101 WAVEFORM TRANSLATOR. This unique instrument converts high speed repetitive waveforms displayed on an oscilloscope to signals which, when applied to an X-Y recorder, reproduce the waveform as a permanent, inked record.

1-9. EVENT MARKER. A third pen, when ordered as an optional feature, is mounted in a fixed position near the bottom of the pen carriage. The purpose of this pen is to insert identifying marks on the lower margin of the chart. It may be actuated by a remote contact closure in the operation system circuitry to designate significant "events" during the test procedure.

1-10. TYPE A-1 AC-DC CONVERTER. Any two axes of the recorder may be used for plotting AC signals by using this two-channel device which supplies a DC voltage proportional to the positive peak amplitude of the AC input signal. Frequency response of the converter is 20 cps to 100 KC. A Type A-1R is available for rack mounting.

WARNING: When accessory equipment designed for a 20,000 ohm load is used, care must be exercised to provide correct recorder input loading. A 20,408 ohm, 0.1%, resistor connected across the recorder input terminals provides the necessary load. Some accessories require different loading. Refer to the accessory operating manual for this information. Moseley Model 17003A provides the necessary shunt and conveniently plugs into the input receptacles. It is also equipped with GR input receptacles.

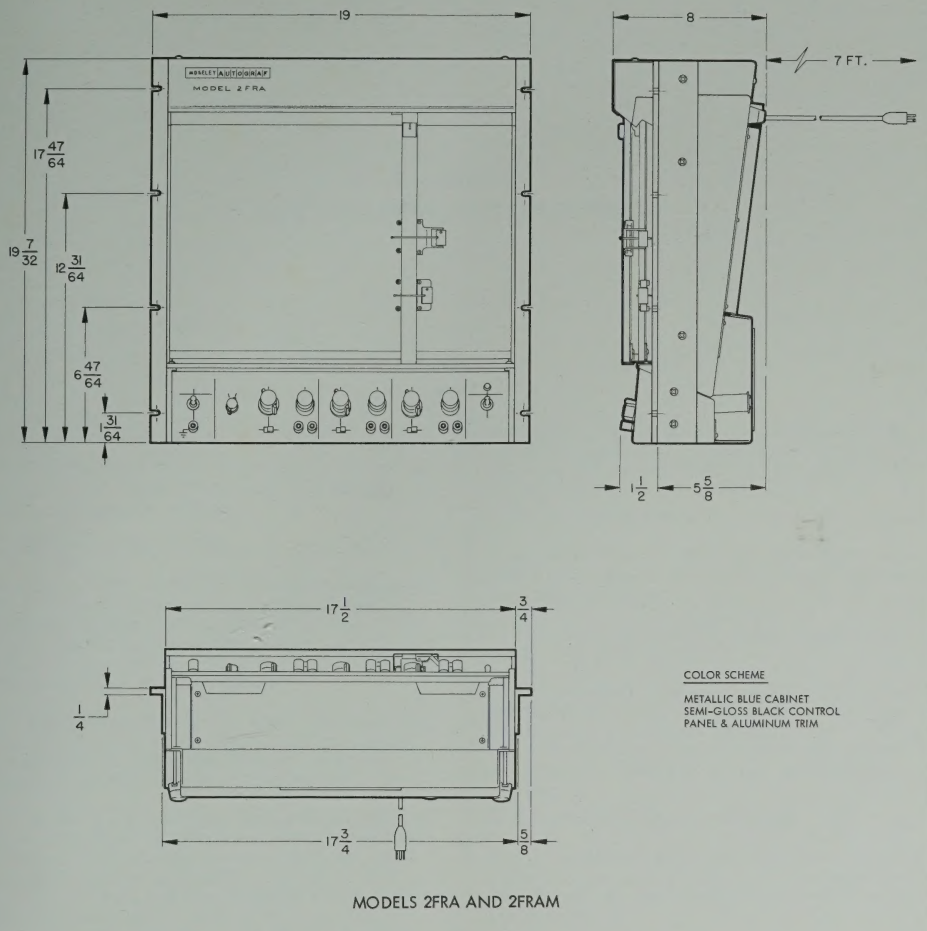


FIGURE 1-2. PHYSICAL DIMENSIONS

SECTION II
INSTALLATION AND INSPECTION

2-1. INTRODUCTION

2-2. This section supplies information for incoming inspection, installation of recorders and recorder options, storage, and shipping.

2-3. INCOMING INSPECTION

2-4. MECHANICAL CHECK. If there is evidence of damage to the shipping carton, ask that an agent of the carrier be present when the instrument is unpacked. Inspect for mechanical damage, scratches, dents, broken knobs, etc. Also check the cushioning material for signs of severe stress.

2-5. PERFORMANCE INSPECTION. The electrical performance should be verified as soon as possible after receipt. A performance inspection chart, figure 2-2, outlines suitable procedure.

2-6. CLAIM FOR DAMAGE. If there is evidence of mechanical damage or failure to meet specifications on receipt, notify the carrier and nearest Hewlett-Packard field office immediately. (A list of field offices is in the back of this manual.) Retain shipping carton and padding material for inspection by the carrier. The field office will arrange for the repair or replacement of your instrument without waiting for settlement of a claim against the carrier.

2-7. STORAGE

2-8. If the instrument is to be stored for an extended period of time both pens should be removed and the carriage arm and pen carriages secured to one side to prevent damage during handling. Seal the instrument in a moisture proof covering and repackage in a container similar to the original factory carton.

2-9. SHIPPING

2-10. Before returning the instrument for any reason, notify the local field sales offices of the difficulty encountered, the model and serial number of the instrument, and request shipping instructions. The following precautions should be taken when repackaging for shipment.

1. Remove both pens.

2. Secure the carriage arm and both pen carriages to one side of the recorder to prevent movement while in transit.

3. If being returned for repair, do not send power cord or accessory kit.

4. Wrap the instrument in heavy paper or plastic and surround with three to four inches of shock-absorbing material to cushion and prevent movement inside the shipping container. The container should be sufficiently durable to prevent damage during handling.

2-11. INSTALLATION OF RECORDER

2-12. The Models 2FRA and 2FRAM are designed for rack mounting in standard 19" rack consoles. Dimensions and clearances are provided in figure 1-2 of section I.

2-13. Cooling is provided by an exhaust fan. The location or mounting of the instrument must insure adequate air circulation.

2-14. INPUT CONNECTIONS. Front input connectors are provided for all three axes on standard instruments. On option initiated with order, rear input terminals may be provided.

2-15. INSTALLATION OF OPTIONS. All recorders in the series may be equipped with optional accessories which increase versatility and use under special operating requirements. Various options are described in paragraph 1-5. They may require factory installation or be furnished in kits for customer installation.

2-16. REAR INPUT TERMINALS. Rear mounted connectors wired in parallel with the regular front terminals are usually factory installed as an ordered option. When omitted initially, a kit may be obtained for installation by the user. Simple instructions are included with the kit.

2-17. EVENT MARKER (LOWER AXIS). This is preferably a customer ordered factory installed option. Customer installation is slightly more complicated but can be accomplished with the instructions furnished.

REQUIRED INSTRUMENTS

a. DC Standard 1 volt - 50 MV-50 Volts.

b. Ohmmeter - 0 - 2 megohm range.

c. Functional step generator.

INSPECTION (Refer to section I for specifications.)

See section III for complete operating procedures.

1. Set the 115/230 selector switch at 115 volts. If 230 volts is the only available power source, set the selector at 230. Before applying power, check the fuse for proper value. A 2 ampere fuse is required for 115 volt operation and a 1 ampere fuse for the 230 volts.

2. To apply power to the recorder, place power switch in ON-ON position.

3. Check for proper operation of the remote pen lift. With the PEN-TIME switch in STANDBY, place the furnished plug in the REMOTE PEN jack on the rear of the instrument and short circuit the plug contacts. Pen should drop into writing position.

4. CALIBRATION AND ALIGNMENT CHECKS. Set both Y-axis range selectors to 0.1 volts/in and position the pen by use of the zero controls to "0" on each Y-axis and seven and one-half inches on the X-axis (mid scale). Apply a one volt DC signal to both Y-axis input terminals. The pens should be driven to 10 on the Y-axis and should not vary from the seven and one-half inch grid line. (Vertical alignment check.) A similar test is made on the X-axis with a one and one-half volt signal to drive the pen 15 inches. Set the X-axis range selector to 0.1 V/in and position the pen by use of the zero controls at "0" on the X-axis and five inches (mid scale) on the Y-axis. Apply a one and one-half volt DC signal to the X-axis input terminals. The pen should be driven to "15" on the X-axis and should not vary from the five inch grid line. (Horizontal alignment check.)

5. LINEARITY AND RESETTABILITY. Using the zero control, set the pen at the 10 inch mark on the Y-axis at approximately half scale. Set the range selector to 0.1 V/inch. Using a step attenuator, start with 0.1 volt and increase in steps of 0.1 volt until full scale is reached. Each step should line up with the major vertical grid divisions. At each step rotate the X-axis zero control to draw a reference line. This provides a linearity check. At the "0" mark on the Y-axis move the pen one division (0.1 inch) to either side. Remove the full scale voltage in steps of 0.1 volts. Each step should line up with the marks made during the linearity check. This demonstrates linearity and resettability. Repeat the procedure using 15 steps of 0.1 volts each in the X axis to determine linearity and resettability of that axis.

6. VARIABLE RANGE. Set the FIX-VAR switch to VAR and the RANGE selector at .1 V/inch; apply a 1 volt signal. Rotation of the VAR control should move the pen along the axis being checked. The variable control is operating properly if any deflection is observed. Usually movement is about 1/5 full scale.

7. TIME SWEEP CHECK. A preliminary check on the X-axis time sweep operation may be obtained using a stop watch as follows:

a. Set the FUNCTION switch to TIME.

b. Set the PEN-TIME switch to UP-RESET.

c. Set the X-axis RANGE switch to 50 secs/div. (or 20 secs/cm).

d. Move the PEN-TIME switch to SWEEP, at the same time starting stop watch.

e. Sweep error should not be greater than ±2.5 seconds per division (1 sec/cm). If sweep operates, although error is high, recalibration may be required. (See section V.)

8. INPUT RESISTANCE CHECKS. Input resistance measurement should not be attempted by using an ohmmeter, a special test procedure and circuit is required. Simply measuring input resistance with an ohmmeter will give erroneous indication.

a. Construct a test circuit as illustrated in figure 2-2.

b. Set the record attenuator control in the axis to be measured to the 0.5 millivolt/division range and adjust recorder zero control to position the pen at zero.

FIGURE 2-1. INCOMING CHECK CHART (Sheet 1 of 2)

c. Connect the low impedance, low voltage source to the input terminals as shown. (Observe polarity.)

d. With the adjustable two megohm potentiometer at zero resistance, adjust the 1K potentiometer for 10 inches pen deflection.

e. Increase the resistance of the two megohm potentiometer until the pen returns to the 5 inch scale position. At this point, the portion of the two megohm pot remaining in the circuit should measure one megohm, matching the input resistance of the recorder.

f. Higher ranges may be checked in a similar manner, using a higher voltage source.

9. ZERO OFFSET CHECK. The 2FRA is provided with one full scale of zero suppression in all axes. Set zero on the X-axis at the "0" mark (left hand margin). Apply a voltage which will drive the pen to the full scale mark (15" or 38 cm). Only sufficient voltage to drive the pen full scale should be applied. Turn the zero control fully CCW. This will reset zero, with the input voltage still applied, to approximately "0." A similar check may be performed on Y_1 and Y_2. If the exact DC voltage required for full scale deflection is not available, the variable range control should be utilized to produce full scale deflection.

FIGURE 2-1. INCOMING CHECK CHART (Sheet 2 of 2)

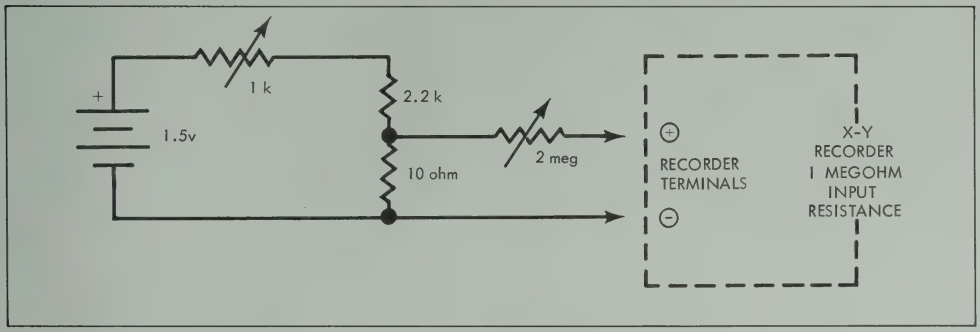


FIGURE 2-2. TEST CIRCUIT

SECTION III
OPERATION

3-1. INTRODUCTION

The basic function of the Model 2FRA and 2FRAM is to produce graphic tracings showing the relationship between two dependent variable functions and a third independent variable. Electrical signals representing these functions are applied to the input terminals of the respective axes of the instrument and the controls adjusted so that the resulting graphs will cover the desired scope of operation. Before operating, the user should become familiar with the input requirements and various control functions as outlined in the following paragraphs.

3-2. ELECTRICAL REQUIREMENTS

3-3. OPERATING POWER. Line power source may be either 115/230 volts, 50/60 cps, and single phase. A voltage conversion switch is located on the rear of the instrument. This switch must be set to either 115 or 230 as determined by the available power source. For optimum performance it is essential that the third prong of the AC power plug be grounded.

3-4. INPUT DATA SIGNALS. Input terminals must be supplied with DC signals which are linear functions of the original information. These signals must vary at a rate within the response capabilities of the instrument (10 inches/sec in the X-axis; 20 inches/sec in both Y-axes) and have amplitudes within its scale ranges, (0 to 50 volts/div (inch)). In the metric model these limits are 25 cm/sec in the X-axis; 50 cm/sec in both Y-axes; 0-20 volts/cm maximum amplitude.

3-5. INPUT CONNECTIONS. The input terminals for all three axes are located on the front panel. Rear input terminals are offered as an optional feature.

3-6. POTENTIOMETRIC INPUT. For maximum sensitivity with minimum current drain from the signal source, the recorder may be converted for potentiometric input on the four most sensitive ranges. Full scale deflection is then obtained with 7.5 millivolts on the X-axis and 5.0 millivolts on each Y-axis. To accomplish this conversion, busses must be removed from the input printed circuit board in the axis or axes desired. The busses are identified in figure 3-3. When the recorder is used in this manner the range switch must select one of the four most sensitive settings. This essentially provides four ranges of potentiometric operation. In this mode, the source impedance of the signal should be 50,000 ohms, or less.

MODEL 2FRA			
Switch Range	Full Scale Input Resistance (ohms/volt)	Full Scale (10") Current Drain (micro-amperes)	Full Scale (10") Input Resistance (ohms)
0.5 mv/div (inch)	200,000,000	0.005	1,000,000
1	100,000,000	0.01	1,000,000
5	20,000,000	0.05	1,000,000
10	10,000,000	0.1	1,000,000
50	2,000,000	0.5	1,000,000
0.1 v/div (inch)	1,000,000	1	1,000,000
0.5	200,000	5	1,000,000
1	100,000	10	1,000,000
5	20,000	50	1,000,000
10	10,000	100	1,000,000
50	2,000	500	1,000,000

FIGURE 3-1. INPUT CHART

MODEL 2FRAM			
Switch Range	Full Scale Input Resistance (ohms/volt)	Full Scale (25 cm) Current Drain (micro-amperes)	Full Scale (25 cm) Input Resistance (ohms)
0.2 mv	200,000,000	0.005	1,000,000
0.5	80,000,000	0.0125	1,000,000
2	20,000,000	0.050	1,000,000
5	8,000,000	0.125	1,000,000
20	2,000,000	0.500	1,000,000
50	800,000	1.250	1,000,000
0.2 v/cm	200,000	5.0	1,000,000
0.5	80,000	12.5	1,000,000
2	20,000	50.0	1,000,000
5	8,000	125.0	1,000,000
20	2,000	500.0	1,000,000

FIGURE 3-2. INPUT CHART

3-7. OPERATING CONTROLS

3-8. CHART-PWR SWITCH. Controls instrument power. It has three positions:

a. OFF-OFF: All power to the instrument is off.

b. OFF-ON: Power is applied to all electrical components except the AUTOGRIP system.

c. HOLD-ON: All electrical components of the instrument are energized, including the AUTOGRIP electric paper holddown.

3-9. PEN-TIME SWITCH. Governs the mode of the recording pen.

a. STANDBY: The pen is raised off the paper, chopper and motor reference phase is turned off. Used during paper loading.

b. UP-RESET: The chopper is energized and all other power is applied to the instrument. The recorder may be run through its complete range for adjustment of range and zero settings to accommodate the data to be recorded. The pen remains raised and no recording is made. When in TIME mode, the pen carriage is returned to zero (or start) following a sweep initiated by the RECORD-SWEEP position.

c. RECORD-SWEEP: The pen is lowered to the paper. Input data will cause the servo system to move the pen, creating the desired inked record. When in TIME mode, this position lowers the pen and initiates the sweep action.

3-10. FUNCTION SWITCH. Controls mode of X-axis range switch only:

a. VOLTS: Range switch selects normal voltage recording capability.

b. TIME: Range switch selects internally generated time sweeps. The RANGE calibrations in millivolts designate the sweep intervals in "seconds/division" (inch), or seconds/centimeter for the metric model.

3-11. RANGE SELECTORS. Both stepped and continuously variable controls are provided for each axis. The scale positions are calibrated in volts/division (inch) for the Model 2FRA and volts/centimeter for the Model 2FRAM. Below each selector knob is a FIX-VAR switch for selection of either fixed or variable range. In the "FIX" position, ranges are fixed and calibrated as marked; in the "VAR" position, the maximum voltage acceptance of any range setting can be continuously extended to several times the indicated fixed setting by a concentric knob on the RANGE selector. This feature is useful in fitting experimental data to any portion of the graph. The volts/division (inch) or volts/centimeter calibration, as determined by the position of these controls, does not change with the setting of the zero control. With the X FUNCTION switch in TIME, the millivolt readings of the X-Range selector indicate sweep speeds.

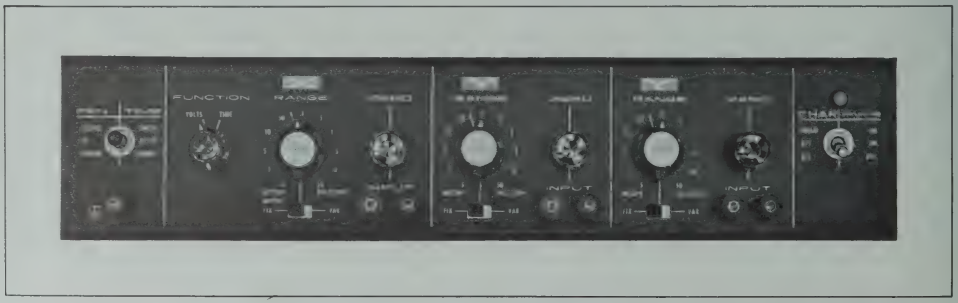


FIGURE 3-3. CONTROL PANEL

CAUTION: Input potentials should never exceed 750 volts on the X-axis or 500 volts on the Y-axes. The variable range extender is intended to increase the versatility of the instrument, not its maximum voltage range.

3-12. ZERO CONTROLS. Ten turn potentiometers on each axis permit placement of electrical zero anywhere on the paper, or suppression up to one full scale to the left and below the lower-left corner of the paper, regardless of the RANGE selector setting. Hence, through proper adjustment, data can be plotted in any desired quadrant.

NOTE: To prevent strain on the servo drives, the zero scale offset should be employed only to counteract a steady-state input which drives the graph toward full scale, or to reposition the minimum point at scale zero. It should not be used to establish the minimum point off the paper, causing the servo drives to exert a continuous force against the stop mechanism.

3-13. OPERATION PROCEDURE

3-14. CONDITIONS OF OPERATION. For satisfactory operation, the phenomena to be recorded must:

a. Be reduced to a DC current, the available voltage being a linear function of the original information.

b. Have amplitudes within the scale ranges of the recorder.

c. Vary in level within the response capabilities of the instrument.

3-15. DC OPERATION. Provided the above signal conditions are satisfied, the recorder may be placed in operation as follows:

a. Set the voltage conversion switch to a setting corresponding to the voltage available. For a 230 volt source, fuse should be 2 amperes; for 115 volts, 3 amperes. Connect power cord to power source, turn CHART-PWR switch to OFF-ON, and allow approximately ten minutes to reach a stabilized operating temperature.

b. Using a hypodermic syringe, inject a supply of recording ink into the pen reservoirs. Do not fill completely. Force ink into the pen tip by inserting an empty syringe into the filler opening and squeeze to apply air pressure.

c. Load paper as follows:

(1) Set the CHART-PWR switch to OFF-ON and the PEN-TIME switch to STANDBY.

(2) Install a sheet of graph paper on the recording platen, aligning lower left edges with corresponding table guides.

(3) Set CHART-PWR switch to HOLD-ON, thus activating the AUTOGRIP system. Adjust and smooth paper as necessary.

(4) Set PEN-TIME switch to UP-RESET.

d. Connect the signal voltages to be recorded to the input terminals and set the scale range selectors to the expected maximum values.

e. Data may now be dry run to insure adequate range and desired positioning on the paper. To record, set PEN-TIME switch to RECORD-SWEEP.

f. To establish accurate zero offset, connect a desired offset voltage to that axis and adjust the ZERO control to bring the carriage or pen index into exact agreement with the "0" mark on the corresponding scale.

3-16. TIME BASE OPERATION. The time base operates on the X-axis only. To record variable functions versus time, proceed as follows:

a. Prepare recorder and load paper as described in paragraph 3-15.

b. Set the FUNCTION switch to TIME.

c. Select the desired time sweep on the X-range switch.

d. Connect Y input data and select desired voltage ranges on Y range switches.

e. Position recording with range and zero controls. Dry runs may be made by removing pen from its carriage.

f. Set the PEN-TIME switch to UP-RESET.

g. Move PEN-TIME switch to SWEEP to actuate recording.

3-17. REMOTE CONTROL OF PEN-LIFT. When operating with accessory equipment it is often desirable to actuate the pen-lift mechanism from an external control. For convenience in this type of operation, a jack marked REMOTE-PEN is provided on the rear of the instrument. A contact closure applied to this jack will cause the pen to lower to the paper and remain down for the duration of the recording.

3-18. PEN ASSEMBLY. The assembly consists of a drum type reservoir resting in a pivot mount which moves along the carriage beam. A rigid capillary tube feed line leads from the reservoir to the pen point. The pen is raised from the paper by a lever system operated by an electromagnet to lower the pen to the paper.

3-19. OPERATING PRECAUTIONS

3-20. The CHART-PWR switch applies 115 volts, 60 cps power to the fixed phase windings of the three drive motors and the vacuum pump motor. Simultaneously, 6.3 volts is applied to the chopper. To

lower the power dissipation and avoid unnecessary wear to the balancing potentiometers, vacuum pump and other mechanical parts when not actually operating, the CHART-PWR switch should be set to OFF-ON and the PEN-TIME switch to STANDBY.

3-21. When a voltage in excess of the RANGE setting is applied to any one of the three sets of input terminals, the pen carriage or pen beam (depending upon the axis involved) will be rapidly driven full scale and strike the stops. If this condition prevails for any length of time, the high voltage may cause component failure. The motor will continue running due to a slip-clutch arrangement, resulting in motor overheating and excessive clutch wear.

3-22. Operation on the most sensitive input ranges from a very low impedance source such as battery or thermocouple voltages may require a reduction in gain to prevent instability. Refer to paragraph 5-13 for gain adjustment procedures.

3-23. Operation on the most sensitive input ranges with no input will result in relatively little to no "null." This can be overcome by shunting the input terminals with a 10K resistor. When an input is applied to the recorder, remove the shunt.

3-24. TYPICAL RECORDING PERFORMANCE. Figure 3-4 shows actual recorder performance. These curves were drawn on a normal production recorder. Lines 2, 3, and 4 were drawn by using a hand operated signal source similar to the test generator, figure 5-5. Curves 1 and 5 were produced by recording current vs voltage of a type 1N34 diode. All recordings of figure 3-4 show "original trace" and "retrace" characteristics. This clearly illustrates any servo dead zones or lag.

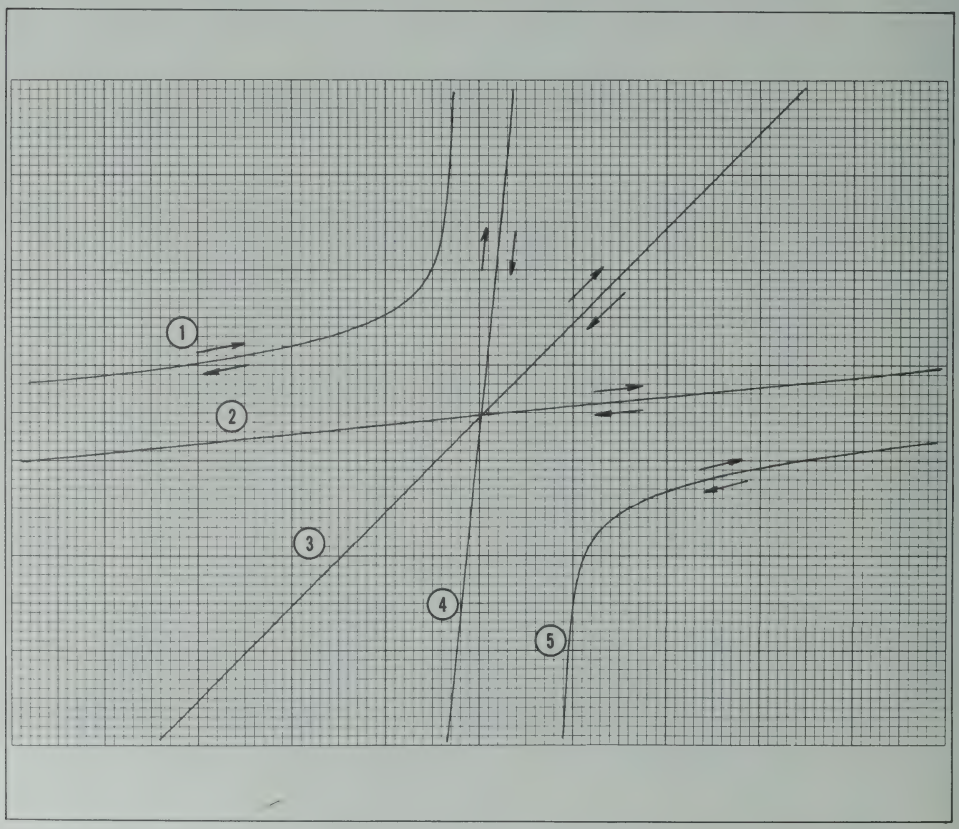


FIGURE 3-4. PERFORMANCE CURVES

SECTION IV
PRINCIPLES OF OPERATION

4-1. GENERAL OPERATION DESCRIPTION

4-2. SERVO MECHANISM. Models 2FRA and 2FRAM have three identical but independent self-balancing servo-mechanisms, isolated from ground. In operation, one servo-mechanism moves the entire carriage (including both pens) in a horizontal direction, and the other two servos move their respective pens in a vertical direction in response to input signals representing the data applied to the respective input terminals. The resulting relative motion of the servo-mechanisms traces cartesian coordinate graphs of the relationships on the paper.

4-3. FIXED AND VARIABLE RANGE CONTROLS. The basic voltage range of the servo systems is 0 to 5 millivolts DC for each Y-axis, and 0 to 7.5 millivolts DC for the X-axis. Operation with greater voltages is obtained by insertion of precision resistors in the balancing circuit. Each range step may be made continuously variable by operation of a transfer switch which inserts a variable potentiometer. Adjustment of this control increases the range span selected by the range selector so that an arbitrary voltage may drive the recorder pen to full scale. The range setting is selected to confine the input data within the travel limits of the instrument.

4-4. BALANCING ACTION. After passing through the attenuator, the input signal is applied to the balance circuit where it is cancelled by an internally supplied opposing voltage. Under these conditions, there is no signal output from the balance circuit and the servo system is at null. When the input signal changes to a new value, an unbalanced condition exists. The error signal (voltage difference) is applied to the chopper which converts the DC voltage to a 60 cycle AC form. The AC output of the chopper is amplified and applied to the control winding of a two phase servo motor. Due to mechanical coupling between the motor and rebalance potentiometer, the balance voltage changes value until it cancels the new input signal. If the input data is constantly varying at rates within the capabilities of the instrument, this rebalancing action is continuous. Therefore, the positions of the rebalance potentiometers and the pens are always directly proportional to the amplitudes of the signals at the respective input terminals.

4-5. TIME BASE. Use of the X-axis as a sweep circuit is determined by a function switch on the front panel. The time base operates on the principle that the charging current drawn by a capacitor will assume a constant value when the controlled charging voltage is increased at a uniform rate. With the addition of minor circuitry, existing facilities of the recorder are utilized to apply an increasing linear voltage to the X-axis servo amplifier causing the pen to advance at a uniform rate dependent on the constants switched into the circuit. The numerical values of the millivolt steps of the X-axis range selector represent sweep speeds.

4-6. CIRCUIT DESCRIPTION

The three axes use identical electronic circuits except for the addition of a time sweep circuit in the X-axis. Although the circuits are identical, certain component values may be varied slightly during manufacture to equalize the responses of the individual axes. Figure 4-2 is a simplified one megohm input circuit to aid in following the attenuator descriptions. Because the three axes are identical, circuit symbols refer to the Y_1-axis unless otherwise noted.

4-7. INPUT ATTENUATOR. Each pair of input terminals connects to a precision voltage divider which determines the maximum allowable input voltage range. The DC input attenuator is composed of four precision ±0.1% wirewound resistors. The resistors forming the attenuator in the Y_1 axis are R-101 through R-104. With the selector switch set to 0.5 millivolt/division (0.2 millivolts/centimeter in the metric unit), the input voltages are applied across a resistance of one megohm and proceed to the balance circuit without attenuation. The voltage

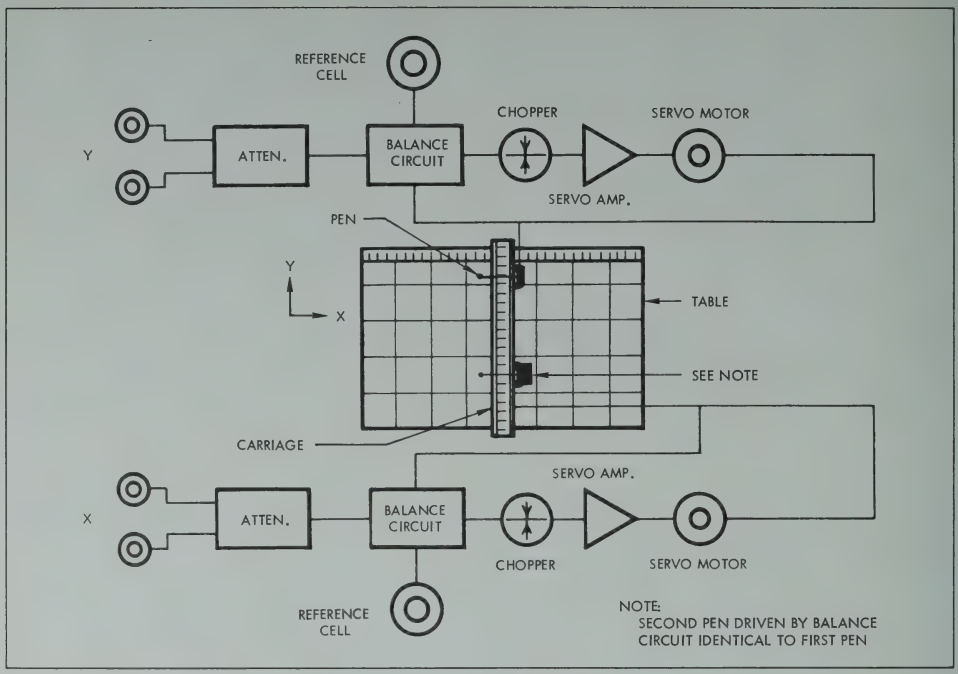


FIGURE 4-1. BLOCK DIAGRAM

in the balance loop is varied by resistors R-107, R-109, and R-110. This allows a signal up to 10 millivolts/division (5 millivolts/centimeter in metric unit) to be applied to the balance circuit without prior attenuation. Input signals greater than this must be attenuated before reaching the balance circuit. The attenuator switch S-101 selects the correct balance resistor for each input range.

4-8. VARIABLE RANGE CIRCUITS. With the FIX-VAR switch S-103 set to VAR, the input voltages are routed through the variable range circuit. This consists of potentiometer R-105 and resistor R-106. Extension of the fixed ranges is effected by varying R-105. No attenuation is inserted by the variable range circuit when operating in the FIX position.

4-9. REFERENCE SUPPLY. The reference voltage for each axis is independently derived from a zener controlled DC power supply, nominally 9V, stable to 0.03% with line variation of ± 10%. The primary of transformer T-801 is supplied with 115 VAC. The rectified output from diodes CR-811 and CR-812, filtered by C-803 and R-808, is applied to zener diode CR-810 which is of high regulating ability. CR-810 reduces the line voltage variation which may appear in the rectified output. Diode CR-809 is a zero temperature coefficient zener diode which further regulates the output of the previous stage for greater precision. This diode is operated at current and voltage levels to provide temperature compensation for the reference supply. Rheostat R-119 is the DC calibration control for the Y_1 axis. The calibrate voltage appearing across the rebalance potentiometer R-801 is adjusted so that the Y_1 servo balances at full scale with 5.0 millivolts.

4-10. BALANCE CIRCUIT. The DC input signal, after passing through the attenuator, is applied to the balance circuit where it is opposed by a DC cancellation voltage from the internal reference supply. The difference between these two voltages, or error signal is converted to AC by a chopper and applied to one winding of the servo motor. The servo motor, M-902, being mechanically coupled to the rebalance potentiometer R-801, drives this potentiometer in a direction to cause the opposing reference voltage to equal and thereby cancel the error signal. The pen, being directly connected to the potentiometer, will move in direct relationship with the error signal until the circuit is balanced and the pen is at null. A ten tune potentiometer, R-117, provides zero control for the Y_1 axis. This potentiometer introduces into the balance circuit a "controlled" error signal which is cancelled in the same manner as an input error signal. This provides a means for placing electrical zero anywhere within the graph limits.

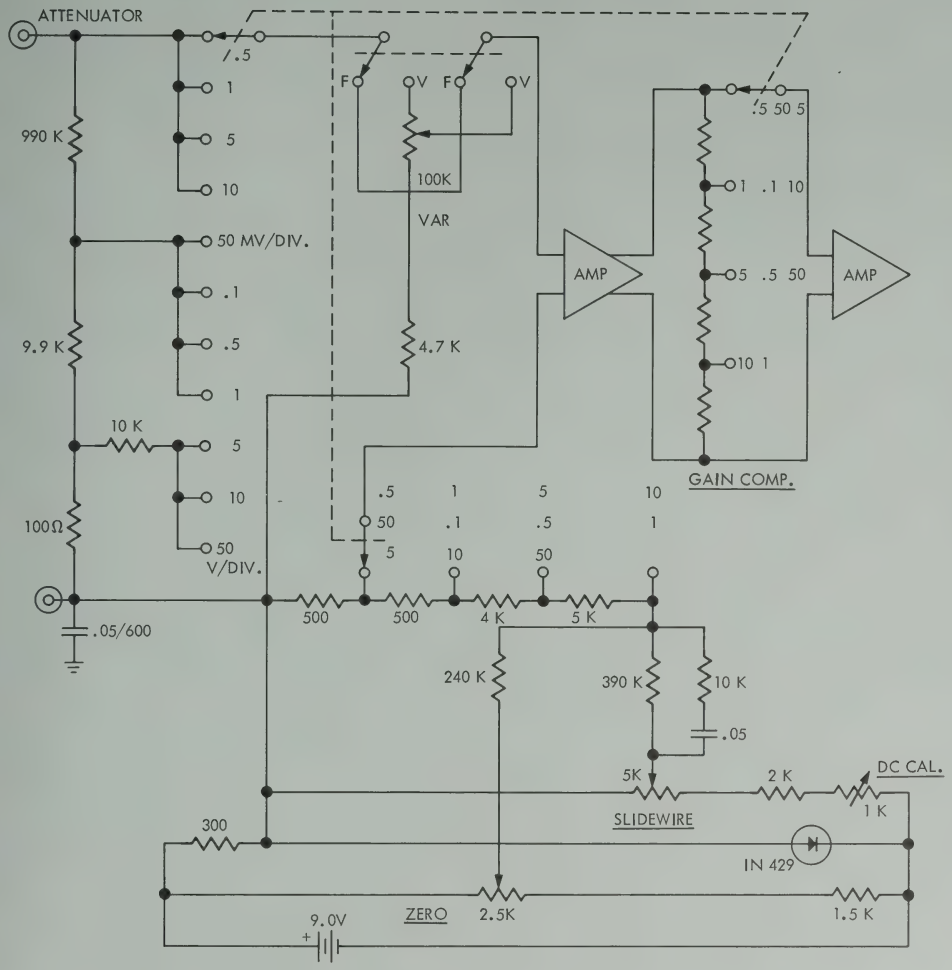


FIGURE 4-2. ONE MEGOHM INPUT CIRCUIT

4-11. CHOPPER AND INPUT TRANSFORMER. The error signal is converted to 60 cps (or 50 cps depending upon the power source) AC by the chopper. As the chopper is driven in synchronism with the power line, the output from the input transformer will be either in phase or 180 degrees out of phase with the line voltage (disregarding chopper lag). Phase relationship is dependent upon the polarity of the DC error signal. The direction of servo motor rotation is determined by the relative phase excitation of its two windings causing the motor to drive the pen and coupled potentiometer in a balance seeking direction. A voltage gain of about 13 is realized in transformer T-501. Under normal operating conditions the magnitude of the error signal never exceeds 5 millivolts in Y or 7.5 millivolts in X and, as the system is sensitive to approximately 0.1% of this voltage, it is evident that the error signals can be exceedingly small, actually in the microvolt region. Because of this, all input circuitry is carefully engineered to minimize interference from stray hum pickup and thermal emfs.

4-12. 1ST, 2ND AND 3RD VOLTAGE AMPLIFIER STAGES. Adequate voltage amplification is provided for the power stages by Nuvistor V-501 and transistors TR-501 and TR-502 in a conventional cascade circuit. Nuvistor V-501 adds needed amplification for the one megohm input condition without increasing background noise. Feedback is supplied from the emitter of TR-502 through R-543 to the base of TR-501. Diodes CR-503 and CR-504 protect TR-501 and TR-502 against overload.

4-13. PHASE INVERTER. The output of the third amplifier stage is coupled to the phase inverter section by C-505. Phase inversion is accomplished in the following manner. A decreasing voltage applied to the base of TR-503 causes a rising voltage to appear at the collector. At the same time, the emitter tends to follow the base potential, i.e., decrease. Since the base of TR-508 is effectively at AC ground potential, the effect of the decreased emitter signal at TR-503 is a rising signal at the collector of TR-508. The overall effect is to produce amplification and phase inversion to the output of TR-502.

4-14. POWER AMPLIFIER STAGES. The push-pull amplifier consisting of TR-504 and TR-507 operates in phase opposition to drive the output transistors TR-505 and TR-506 through transformer T-502. These latter transistors supply power to the servo motors. The major feed-back loop is composed of resistors R-527, R-526 and capacitors C-507, C-512. Sufficient phase change is introduced so that when the phase lag of the chopper is added, the output control voltage to the servo motor is approximately 90° out of phase with the reference winding of that motor.

4-15. POWER SUPPLY. CR-511, CR-512, and C-514 constitute a half-wave rectifier and filter. TR-509 is a series regulator controlling current through voltage divider R-532 and T-531. TR-509 is stabilized by TR-510 whose base is controlled by zener diode CR-509. CR-509 also insures accurate and stable potentials for the low level amplifier stages. Filtered filament voltage for the Nuvistor stages is taken from the half-wave rectifier section and controlled by zener diode CR-501.

4-16. TIME BASE. Available on the X-axis only, this circuit operates on the principle that the charging current to a capacitor remains constant as the charging voltage increases at a uniform rate. By addition of minor circuitry to that existing on the X-axis, the requirements for the time sweep are satisfied. Figure 4-3 is a simplified time base circuit to aid in following the operational description. Circuit symbols correspond to those used on the Model 2FRA schematic (MD-12607) found at the end of this manual.

a. Sweep speeds are determined by the balance voltage. This voltage is provided by the Y-axis balance circuit and attenuated by the sweep range attenuator composed of resistors R-312 through R-321. The voltage drop developed across the charging resistor R-318 or R-319 by the charging current of capacitor C-303 or C-304 is partially cancelled by the preselected balance voltage. The voltage difference is applied to the servo amplifier with the polarity necessary to drive the pen up scale. The balance potentiometer, R-802, being coupled to the pen, will also be driven up scale resulting in a further increase in the charge on capacitors C-303 and C-304 and hence the charging current. This increase tends to balance the decreasing charging current encountered under constant voltage conditions.

b. As there is always a small mismatch between the voltage drop across R-318 or R-319 and the balance voltage, the time sweep action will continue until the RECORD-SWEEP switch, S-901, is closed. When closed, the amplifier input is connected to the X-axis zero control circuit. The zero control potentiometer, R-324, allows positioning of the sweep starting position anywhere on the X-axis. Opening of switch S-901 initiates the timing action just described by eliminating the zero positioning voltage from the circuit. This allows the unbalanced error voltage across R-324 to be applied to the amplifier. An error rate damping network for the input to the servo amplifier is provided by R-336, R-337, C-306 and C-305.

4-17. DAMPING. Capacitor C-103 draws a charging current whenever a change in input occurs, thereby increasing the rate of appearance of the balance voltage across resistor string, R-107, R-109, and R-110. This phase advance in the slowly varying error signal causes an "anticipatory" approach to the balance point, producing damping.

4-18. MOTOR AND MECHANICAL DAMPER. The X and Y_1 servo motors are Moseley 2-phase induction types. The Y_2 servo motor is a 2-phase Daystrom Transicoil, Type 15. One phase is energized from the AC power line, the other being excited in phase quadrature from the amplifier output. Direction of motor rotation is determined by whether a leading or lagging 90° phase relationship exists. A pinion on the motor shaft meshes with a large aluminum gear which is coupled to the drive sheave through a friction

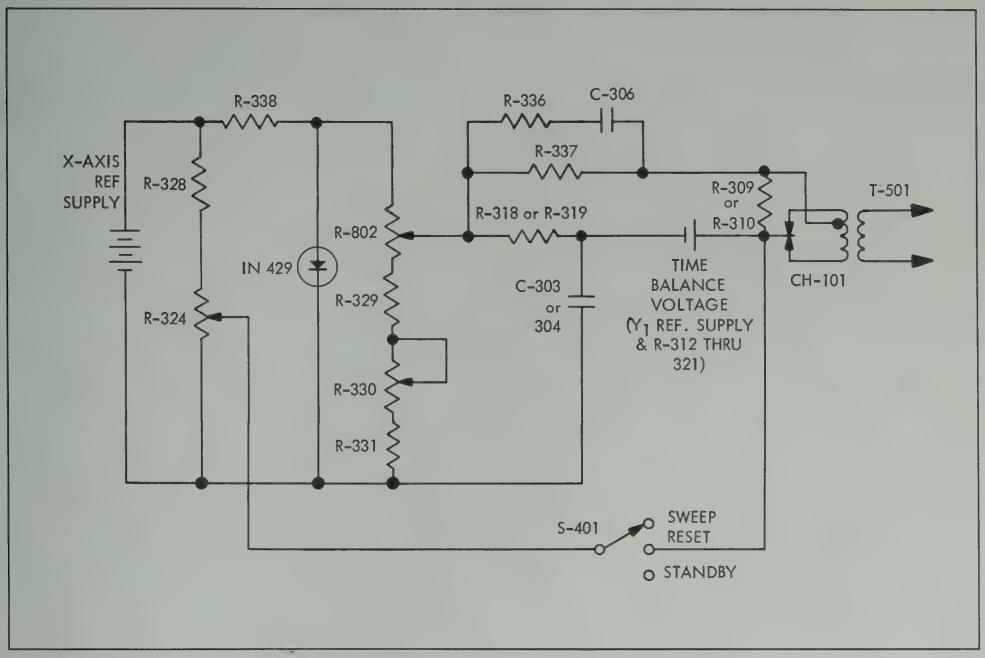


FIGURE 4-3. SIMPLIFIED TIME BASE CIRCUIT

clutch. A mechanical inertia damper is mounted on the opposite end of the armature shaft. Sealed inside the outer case is a metallic mass in viscous silicone oil which damps the operating characteristics of the drive motor, producing a smooth trace when recording.

4-19. AUTOGRIP PAPER HOLDDOWN. This exclusive feature consists of a completely sealed specially constructed platen with integral power supply which develops a strong electrostatic field over the entire table surface. Firm gripping power is efficient on any size graph paper up to the actual size of the platen.

4-20. PEN SYSTEM. The standard pen consists of a metal reservoir, transfer tube, and pen tip. The pen is filled and primed with a syringe supplied in the accessory kit. Once primed the ink will continue to flow through capillary action as used at the pen tip. Because of the capillary process, rack mounted (vertical) models write equally as well as the table models.

SECTION V
MAINTENANCE

5-1. PREVENTIVE MAINTENANCE

5-2. GENERAL. The Model 2FRA must be maintained properly to give accurate, trouble-free operation. This requires periodic lubrication, performance tests, visual and electrical checks. Moseley recorders should always be protected from dust by covering when not in use.

5-3. ENVIRONMENTAL OPERATION. This recorder is not designed to operate under extreme cold or heat conditions. Such operation will produce inaccurate results and may cause permanent damage. In areas with high humidity, graph paper may become stretched with resulting distortion of the grid lines. Operation under conditions of excessive air contamination (soot, smoke, fumes, etc.) will require more frequent cleaning maintenance.

5-4. CLEANING. Thorough cleaning should be performed periodically. Required intervals are determined by the type of operation, local air contamination, and climatic conditions. Under normal use and conditions, routine cleaning should be accomplished every nine to twelve months. To clean the instrument, proceed as follows:

a. Remove the control box, platen, amplifier, and all dust covers.

b. In hard-to-reach areas and where there is only dust accumulation, cleaning can be accomplished with an air gun. In more accessible areas and where the air gun will not remove the dirt, dust, or ink, a cloth or sponge saturated with plain soap and water should be used, then wiped clean with a dry cloth.

c. Bearings (except clutch bearings), gears, and other lubricated components should first be cleaned thoroughly with a solvent and relubricated every eighteen to twenty-four months. Soap and water should not be used on these parts.

d. The platen surface should be cleaned with a compound such as Jet Spray, Bon Ami, or Ajax. These are especially effective in removing dried ink.

WARNING: Use of cleaning solvents of any type should be avoided on the AUTOGRIP platen.

e. Cleaning of pen and slidewires are described under separate headings in the mechanical maintenance section.

5-5. LUBRICATION. The Model 2FRA is a precision instrument with bearings, gears, and other moving parts having very close tolerances. For this reason lubrication should be performed with caution. Over lubrication may produce more friction than a very little. Recommended intervals are determined by type of operation, local air contamination and climatic conditions. Under normal use and optimum conditions every nine to twelve months is adequate. A complete routine including cleaning should be performed at least every two years. A suggested lubrication procedure follows:

1. Do not attempt to clean or lubricate the sealed clutch bearings, or the slider arm which is an oil impregnated bronze bushing.

2. Apply a thin film of Aeroshell Mil-G-7118A or equivalent on the X and Y gear drives (including idler gear).

3. Apply a drop of LO-17 Stanoil #35 or equivalent to the four X axis drive pulley bearings.

4. Servo motor bearings should be lubricated with a drop of Penn-Motor Oil #40 or equivalent. Lubrication of these bearings requires disassembly of the servo motor.

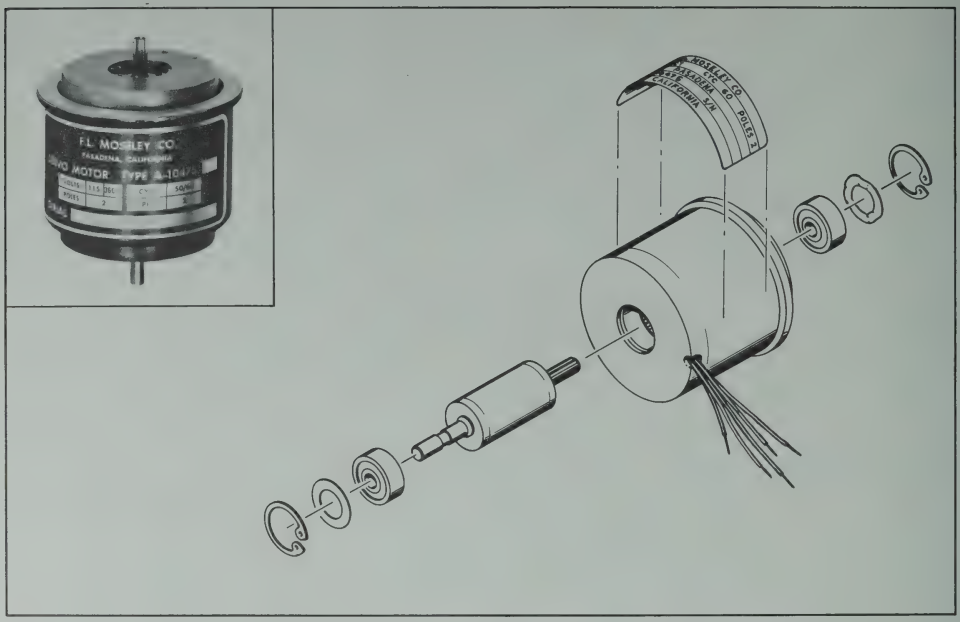


FIGURE 5-1. SERVO MOTOR ILLUSTRATION

CAUTION: Because of very small air clearance between rotor and stator any oil seeping into this area will impair motor operating characteristics.

5. Lubricate springs inside each of the pantograph arms with Plastic Lub # 00 (all purpose), or equivalent.

6. Apply a drop of Stanoil #35 to the three joints and bearings of the pantograph arm. No lubricate is required on the slider rod.

7. Lubricate the two Y-axis drive pulleys with a drop of LO-17, Stanoil #35, or equivalent.

CAUTION: Oil must be prevented from dropping on either slidewire. If it does, the slidewire must be thoroughly cleaned with a solvent.

5-6. VISUAL INSPECTION. During periodic cleaning and lubrication, a routine visual inspection should be performed. Following is a general guide which should not be considered to restrict inspection of other obvious items.

1. Check the X, Y_1 and Y_2 drive gears for proper adjustment (a slight amount of backlash), and any worn or damaged teeth.

2. Inspect X-axis drive cable pulleys and X-axis pantograph arm for any binding.

3. Insure that all servo motors are mounted securely and mechanical dampers are firmly secured to the motors.

4. Tighten mounting screws on the amplifier and any optional plug-in units to insure good electrical contact.

5. Move both pen carriages up and down (independently) listening for scrapes, grinding noises, etc., while feeling for any binding in the movement. Repeat with the carriage arm.

6. Check all axes for fraying or rubbing of drive cables.

7. Component check should include inspection for evidence of overheating, loose connections, broken circuit boards, etc.

5-7. ELECTRICAL MAINTENANCE

5-8. TROUBLE SHOOTING. The concept of "bracketing," i.e., establishing circuits or sections which are not operating at all, or are operating abnormally, is generally the fastest way to locate trouble in a closed loop circuit. Many malfunctions, other than those caused by improper adjustments, may be localized by reference to the Trouble Shooting Chart, Figure 5-11.

5-9. CALIBRATION. Calibration is standardized during manufacture against a Weston Standard Cell. The electronic reference is designed to have negligible drift. Should a long term drive be noted due to a possible change in value of components, recalibration may become necessary. The following procedure should be used:

a. For access to all calibration controls and the input circuit board, pull the control box forward and remove the bottom cover plate.

b. Completely energize the recorder and allow approximately ten minutes to reach a stabilizing temperature.

c. Set the FIX-VAR switches to FIX and the RANGE switches to 0.1 volt/division (50 mv/cm on metric model).

d. Connect an accurately established one volt DC source (as obtained, for example, from an L & N precision potentiometer and Weston Standard Cell) in correct polarity to the input terminals of all three axes (X, Y_1, Y_2). This voltage should drive the carriage and both pens to the upper right portion of the paper.

e. Remove the warning cover and adjust appropriate controls to bring both pens into exact agreement with the "10" mark on the X and Y scales. Removal of the signal should cause the pens and carriage to return to the "0" mark on the scales. Repeat procedure until accurate repositioning is achieved.

f. In the event "10" cannot be reached by adjustment of the calibration controls, the electronic reference supply should be checked for an output of 9.0V (±5%).

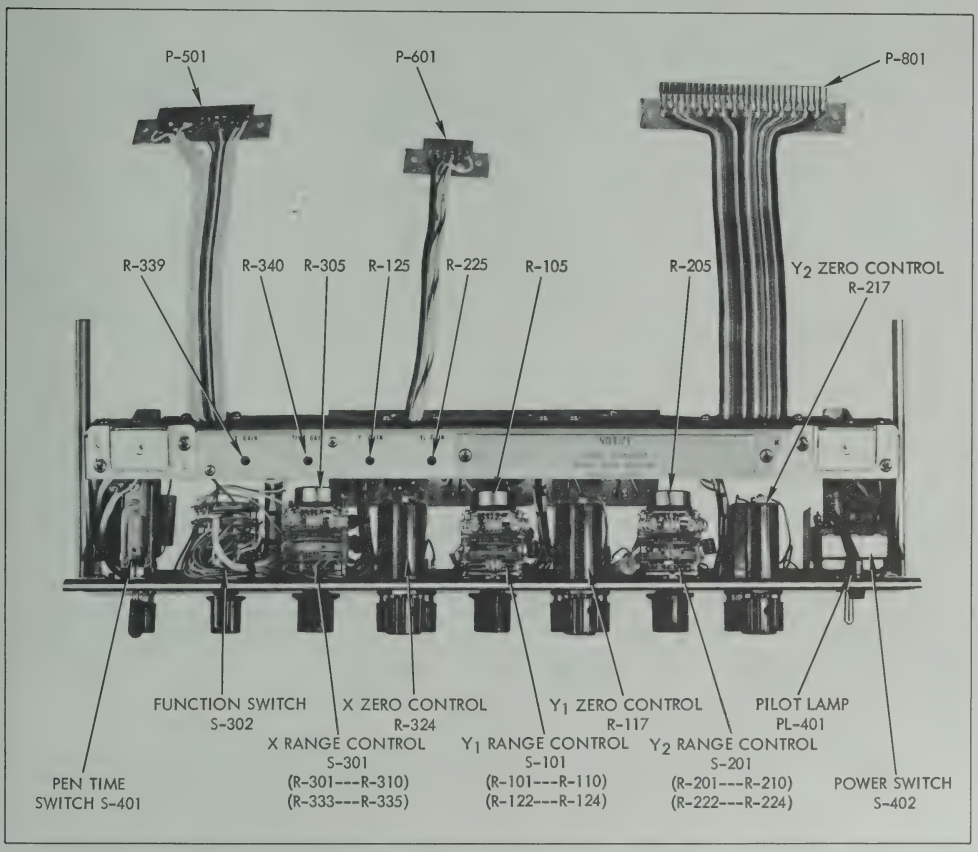


FIGURE 5-2. CONTROL BOX (TOP VIEW)

5-10. TIME BASE CALIBRATION. The various sweep speeds are established during manufacture by special component selection for each instrument and normally will not change appreciably. If recalibration is required due to excessive deviation from the fixed speeds, allow recorder sufficient time to reach a stable operating temperature (approximately ten minutes) and proceed as follows:

a. Check timing accuracy for the 50 seconds/division (20 seconds/cm) speed by using stop watch.

b. If deviation in (a) is greater than ±2.5 seconds/division (1.0 second/cm), recalibration requirement is indicated. For this purpose an accurate time function generator should be available for application to the Y-axis for comparison to the actual X-axis advance. Either Y-axis may be used but the one chosen should be used throughout subsequent calibration procedure.

c. Moderately accurate overall timing calibration may be accomplished by adjusting three potentiometers on the top of the control box (see figure 5-2).

(1) DC calibrate and adjust TIME-GAIN control R-340.

(2) Adjust R-320 (HI) for simultaneous control of first two sweeps.

(3) Adjust R-321 (LO) for simultaneous control of last three sweeps.

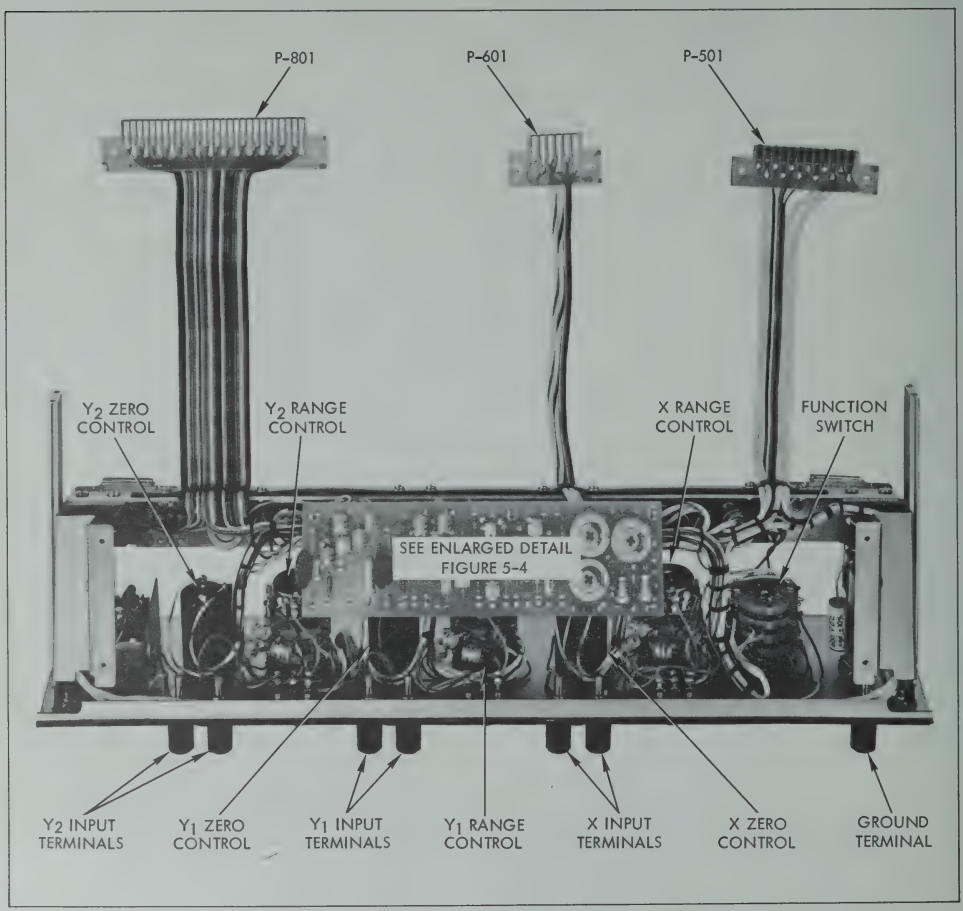


FIGURE 5-3. CONTROL BOX (BOTTOM VIEW)

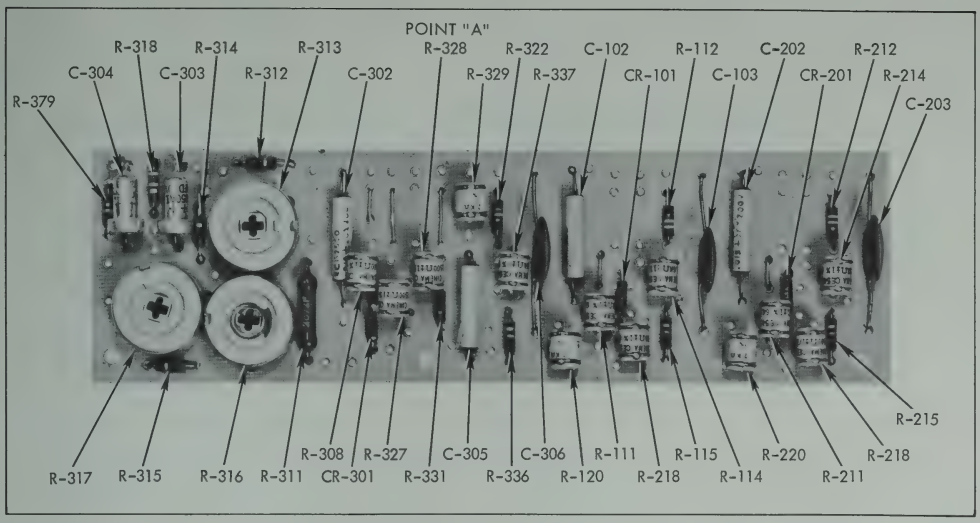


FIGURE 5-4. PRINTED CIRCUIT BOARD (CONTROL BOX)

d. If step (c) is inadequate, complete recalibration is indicated. As the additional potentiometers involved are set and sealed during production, detailed calibration should not be attempted unless absolutely necessary and then only by using an accurate time function generator and proceeding in the following sequence:

(1) Adjust R-320 for 0.5 seconds/division (0.2 seconds/cm).

(2) Adjust R-313 for 1.0 seconds/division (0.5 seconds/cm).

(3) Adjust R-321 for 5.0 seconds/division (2.0 seconds/cm).

(4) Adjust R-316 for 10 seconds/division (5 seconds/cm).

(5) Adjust R-317 for 50 seconds/division (20 seconds/cm).

NOTE: Potentiometers R-313, R-316 and R-317 are grouped together on a printed circuit board on the bottom of the control box.

e. Trouble shooting of the time base may be greatly simplified by referring to Schematic C-13714 which depicts only the time base circuit.

5-11. DAMPING. No damping adjustments are required due to use of a fixed damping circuit. Refer to paragraphs 4-17 and 4-18 for description.

5-12. PERFORMANCE CHECKING. A convenient method for checking overall performance is to apply a smoothly varying DC voltage to two pairs of the input terminals (X and Y) or (X and Y_2) simultaneously. A simple test generator for this purpose may be constructed as illustrated in figure 5-5. If the generator control knob is rotated CW to draw a line and then CCW to draw back along the same line, the result is called a "retrace" curve. The space, if any, between the up-line and the down-line is the "retrace error." The amount of retrace error is governed by the gain setting, damping, and servo system friction and backlash. A correctly operating instrument will exhibit practically zero retrace error. The straightness of the line drawn in this manner is a measure of linearity. A loose pen or carriage system will result in a rough trace; a defective or worn rebalance potentiometer will cause a curved trace.

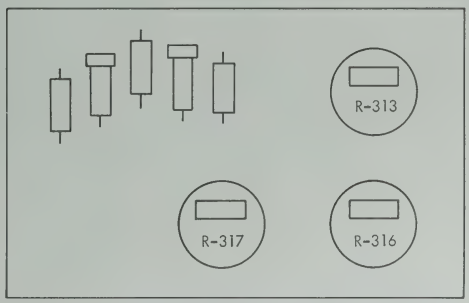


FIGURE 5-5. CALIBRATION POTENTIOMETER LOCATION CHART

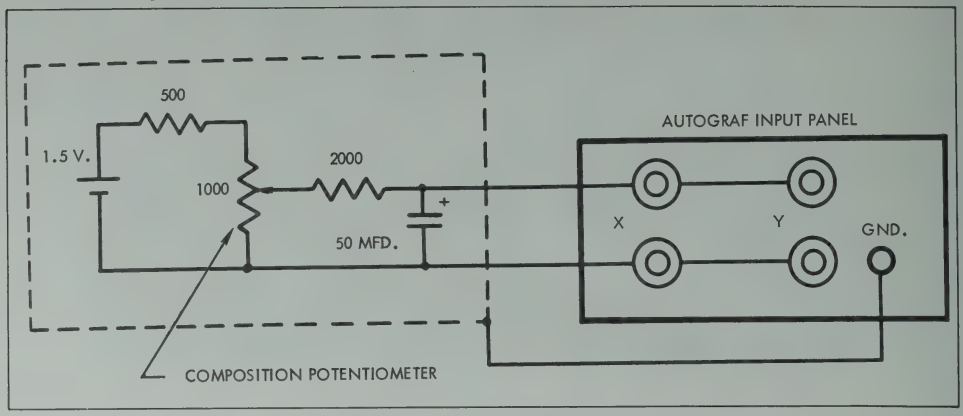


FIGURE 5-6. TEST GENERATOR

5-13. GAIN ADJUSTMENTS. Gain potentiometers are screwdriver adjustments located on the top of the control box. Pull control box forward and adjust as follows:

a. Set the gain potentiometers to a minimum position (fully CCW).

b. Connect Test Generator to two axes as in paragraph 5-6, above.

c. Set the recorder RANGE switches on each axis to 0.1 volt/division (50 mv/cm) for X, and 0.5 volts/division (0.2 volt/cm) or Y_1. Rotation of the test generator control will cause a nearly horizontal line to be drawn. Any retrace error will be due largely to low gain in the Y_1 axis. Adjust the Y_1 gain control for as close to zero retrace as possible. Repeat this procedure for Y_2.

d. Set the RANGE switches to 0.5 volts/division (0.2 volt/cm) on X, and 0.1 volt/divison (50 mv/cm) on Y (either Y may be used). Applying a test signal will cause a nearly vertical line to be drawn. Any retrace error will be due to low gain in the X-axis. Adjust the X gain control for as close to zero retrace as possible.

e. Generally, an optimum setting of the gain controls will produce essentially zero retrace.

5-14. After the X and both Y axes have been optimized for minimum retrace error independently, set both RANGE switches of a pair of axes to identical values. Apply the voltage obtained from the Test Generator to the X and Y_1 axes (either Y-axis may be used). A straight line of 45 degree angle will be produced. Assuming the retrace test demonstrates essentially zero retrace error, or approximately the same error in both axes, any space appearing between the 45 degree lines will be due to a phase difference or time lag between the two recording axes. Phase adjustment is accomplished by altering the value of filter capacitor C-103, C-203 or C-306. If these capacitors are found to be other than 0.05 mfd, phase adjustments were made during manufacture.

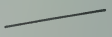
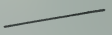
Incorrect		Correct
	Set X on 0.1 v/in. range. Set Y on 0.5 v/in. range. Rock potentiometer control of tester back and forth. Poor retrace indicates insufficient gain in Y channel. (To check X channel, set X to 0.5 v/in.; Y to 0.1 v/in.)	
	Use same settings as above. Rough writing indicates too much gain in axis being tested.	
	Use same settings as above. Roughness appearing in one part of trace is probably due to a worn or dirty balance potentiometer.	
	Use same settings as above. Three cyclic variations in trace indicate gear train mesh is too tightly adjusted.	
	Connect a 1-1/2 volt battery to the Y input. Leave X input open. Slowly rotate zero control while rapidly flipping the Y attenuator knob between 0.5 and 1.0 v/in. positions. Excessive overshoot and oscillation indicates too much gain in Y axis. Repeat for X axis.	

FIGURE 5-7. PERFORMANCE CHART

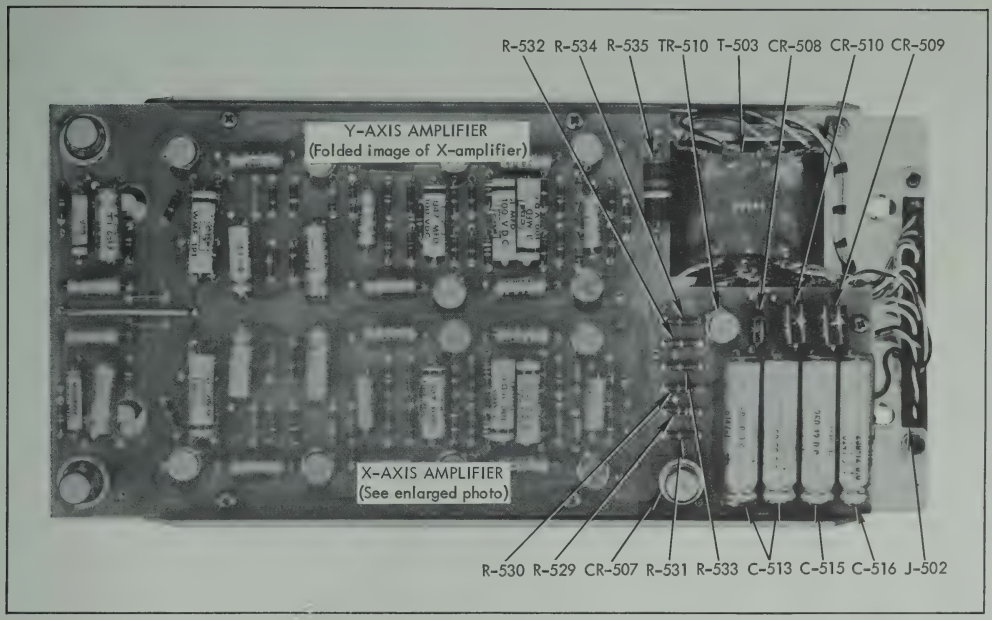


FIGURE 5-8. X-Y AMPLIFIER (BOTTOM VIEW)

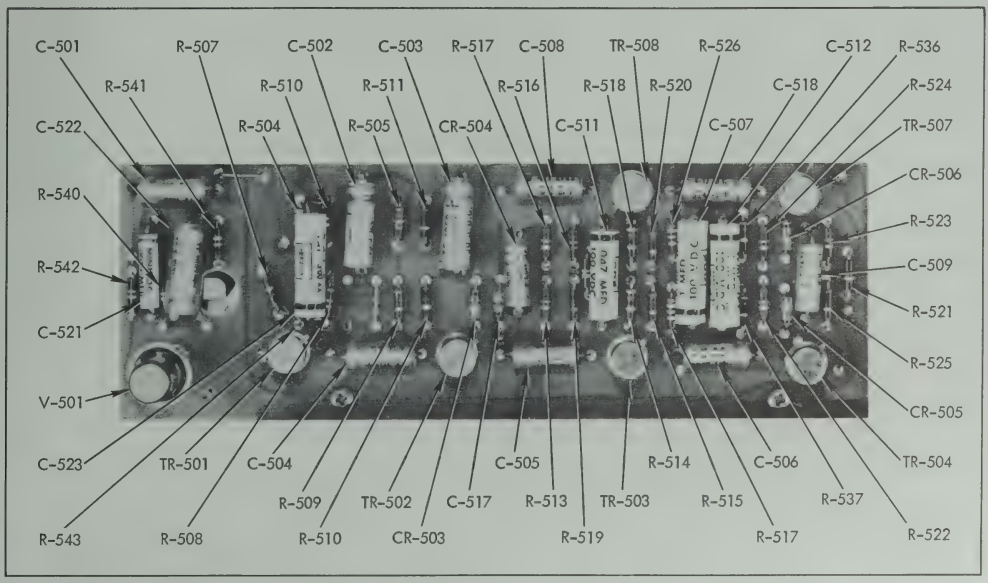


FIGURE 5-9. X-AXIS PRINTED CIRCUIT BOARD

5-15. SERVO STANDBY VOLTAGE. A recorder which is performing properly will have a low "standby" voltage supplying each of its servo motors. This may be checked by placing an AC voltmeter between the collectors of output transistors TR-505 and TR-506. This is equivalent to placing the voltmeter across the control phase winding of the servo motor. A normal standby voltage will range between 3 and 5 volts. If the pen carriage is manually forced from null, the standby voltage will rise rapidly to about 30 volts. At about 15 volts the drive clutch will slip, accompanied by a whirring sound.

5-16. TROUBLE SHOOTING. The following difficulties, other than malfunctions caused by improper adjustment, may be localized by reference to the TROUBLE SHOOTING CHART, figure 5-11.

5-17. LINEAR POTENTIOMETER MAINTENANCE. Irregular or rough plots produced by smooth signals on a properly adjusted recorder indicate a possible worn or dirty rebalance potentiometer. The resistance wire mandrel of the potentiometer may be cleaned with a moderately stiff brush using gentle strokes at right angles to its length, i.e., parallel to the individual turns of fine wire. Care should be exercised during this operation to prevent damage to the fine wire. The solid return wire may be cleaned with a lint free cloth moistened slightly with a solvent, such as Moseley Contact Cleaner Type 391-0001 which leaves no greasy residue. The sliding contact should be adjusted to about a 45 degree angle before installation. Correct contact pressure is approximately 15 grams.

5-18. POTENTIOMETER REPLACEMENT. Under paragraph 5-12 a test is described for checking the rebalance potentiometers. If replacement is indidated, complete assemblies should be obtained from the factory. The following replacement procedures are for earlier models equipped with the "round" mandrel. The present models are equipped with flat mandrel rebalance potentiometers which are permanently fastened to the carriage beam. Replacement of these later potentiometers require replacing the carriage beam assembly. Refer to paragraph 5-25.

a. Y_1-AXIS REBALANCE POTENTIOMETER. This assembly is mounted under the lower carriage beam.

(1) Remove the Y_2 carriage beam (see paragraph 5-26a).

(2) Remove the Y_1 carriage beam (see paragraph 5-26b).

(3) To remove the pen carriage, loosen the two screws in the rollers on the pen tip side. Turn the eccentrically mounted rollers with a stiff wire until the holes are closest to the carriage beam. Slip the nylon cord off the lower pulley.

(4) Unsolder the three wires connected to the potentiometer, noting the color coding to insure correct installation of the new assembly.

(5) Remove the three machine screws holding the potentiometer to the carriage beam.

(6) Install the new potentiometer unit and reassemble.

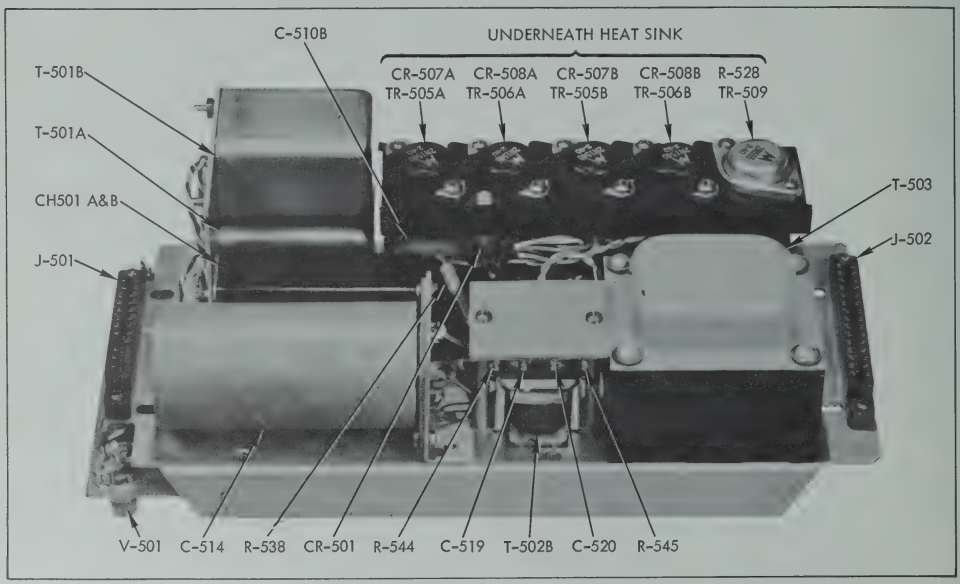


FIGURE 5-10. X-Y AMPLIFIER (TOP VIEW)

b. Y_2-AXIS REBALANCE POTENTIOMETER. This assembly is also mounted under the lower carriage beam.

(1) Remove the Y_2 carriage beam (see paragraph 5-26a).

(2) Perform same operations as for replacement of Y_1 potentiometer.

c. X-AXIS REBALANCE POTENTIOMETER. This assembly is mounted behind the rear panel of the recorder.

(1) Remove the top trim strip, mounted by two machine screws.

(2) Remove the top cover, mounted by four machine screws.

(3) Unsolder the three wires on the right side of the potentiometer noting the color coding to insure correct installation of the new assembly.

(4) Remove the five machine screws holding the potentiometer mounting strip to the frame, also the four screws holding the potentiometer to the mounting strip.

(5) Install the new potentiometer unit and reassemble.

INDICATION	PROBABLE CAUSE	LOCATING CAUSE
1. Sluggish response of zero controls on 4 most sensitive ranges.	1. This condition is normal with no input applied. Short circuit input for normal response (MAX. SOURCE RESISTANCE 50K).	1. N/A
2. Noisy, or rough trace.	1. Instrument not grounded.	1. 115/230 VAC POWER GND. REQ.
	2. Worn or dirty potentiometer.	2. See paragraphs 5-17 and 5-18 for tests and corrective procedures.
	3. Insufficient contact pressure or improper positioning of wiper on slidewire balance potentiometers.	3. Contact at 45° angle before installation with contact pressure of 15 grams (approximate values).
	4. Noisy nuvistor or transistors in amplifier. (Microphone input trans. possible cause.)	4. Check amplifier output transistors, if noise is present check plate of nuvistor. This will localize the trouble to a few components.
	5. Backlash adjustment incorrect.	5. See paragraph 5-26 for desirable setting.
	6. Regulator zener diode for nuvistor filaments defective.	6. Check filament circuit.
3. Dead zone, manifested by inability to obtain an acceptable retrace and/or poor damping.	1. Friction in mechanical linkage.	1. Inspect all moving parts, pantograph arm, gears, bearings, etc.
	2. Loss of voltage gain due to defective component.	2. Check each amplifier stage and the power supply.
	3. Unbalanced output transistors, TR-505 and TR-506.	3. Check the waveforms of each output transistor. Both points should produce identical waveforms.

FIGURE 5-11. TROUBLE SHOOTING CHART (Sheet 1 of 2)

INDICATION	PROBABLE CAUSE	LOCATING CAUSE
4. Sweep velocity decreases and appears non-linear. NOTE: Sweep runs backwards. See cause #3.	1. Low servo gain or loss of gain resulting in loss of hull. 2. Friction in mechanical linkage. 3. Leakage in the 5 and 30 mfd tantalum capacitors.	1. Check the amplifier output and the reference supply. 2. Inspect all moving parts, pantograph arm, gears, bearings, etc. 3. Replace.
5. Interaction between axes.	1. Unbalanced output transistors, TR-505 and TR-506. 2. Microphonic nuvistor or input transformer in amplifier stage. 3. Failure of low voltage supply regulators. 4. Chopper malfunctioning. 5. Defective REGULATOR ZENER DIODE FOR NUVISTOR FILAMENTS.	1. Check the output transistors of each axis, both should produce identical waveforms. 2. Check the signal at the plate of the nuvistor. 3. Check the power supply outputs. 4. Check the signal at the plate of the nuvistor. 5. Check the nuvistor filament circuit.
6. Loss of Vacuum Hold-down on models without AUTOGRIP.	1. Obstruction in intake line. 2. Clogged filter. 3. Pump failure. 4. Leak at O-ring seal (platen and vacuum line). 5. Broken V-belt. 6. Motor inoperative.	1. See paragraph 6-11 for complete vacuum system maintenance. 2. See paragraph 6-11. 3. Same as No. 1 4. a. Tighten platen screws. b. Replace O-ring. 5. Visual inspection. 6. Visual inspection.

FIGURE 5-11. TROUBLE SHOOTING CHART (Sheet 2 of 2)

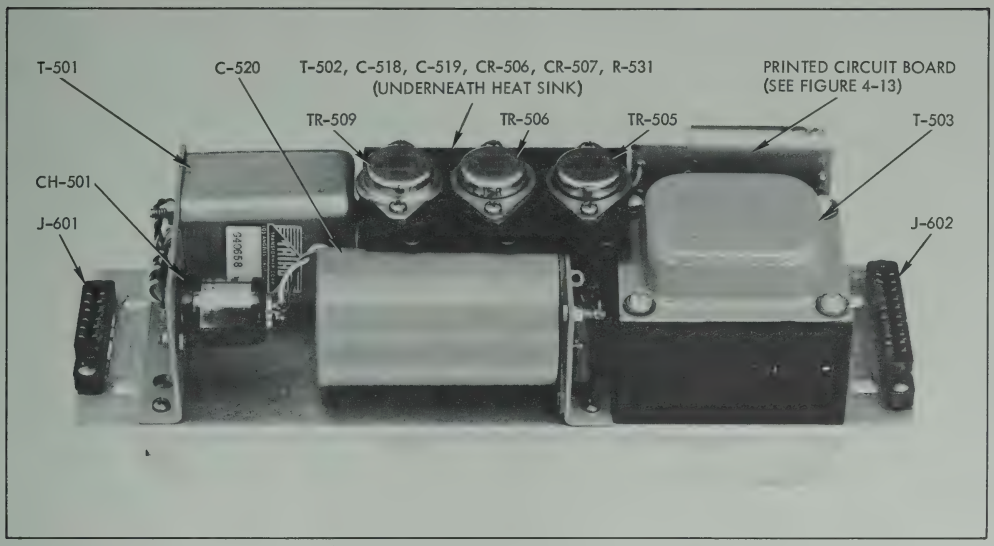


FIGURE 5-12. Y_2 AMPLIFIER (TOP VIEW)

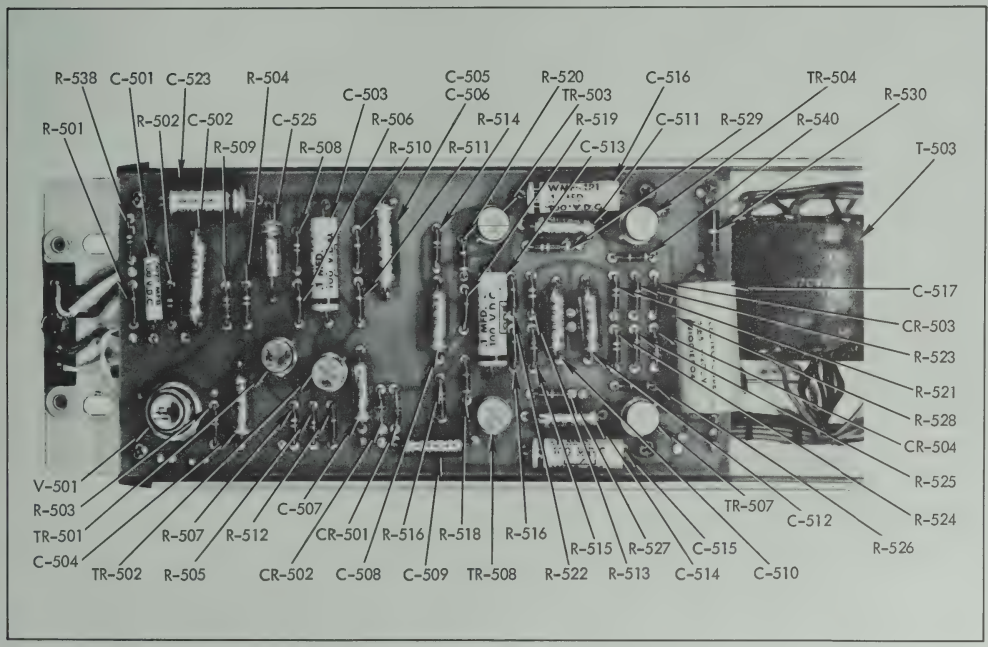


FIGURE 5-13. Y_2 PRINTED CIRCUIT BOARD

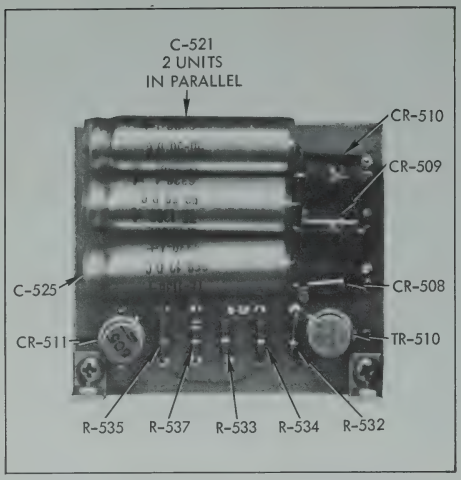


FIGURE 5-14. PRINTED CIRCUIT BOARD (SIDE VIEW)

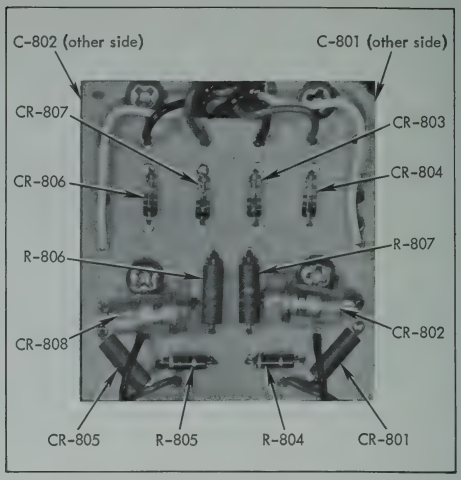


FIGURE 5-15. REFERENCE SUPPLY

5-19. POTENTIOMETER WIPER REPLACEMENT. Rebalance potentiometer wipers are mode of a softer metal than the resistance mandrels and therefore require replacement long before the mandrels. New wiper assemblies are available from the factory.

a. Y-AXIS WIPERS. These assemblies are mounted on the Y_1 and Y_2 pen carriages. New wiper assemblies are Part No. B6335.

(1) Remove the pen from the pen mounting block.

(2) Remove the upper trim strip, mounted by two machine screws.

(3) Remove the Y_2 carriage beam (see paragraph 5-26a).

(4) Remove the Y_1 carriage beam (see paragraph 5-26b).

(5) From the pen tip side, loosen the two screws mounting the eccentric rollers.

(6) Using a stiff wire, position the two rollers to align with the eccentric holes nearest the carriage beam.

(7) Separate the pen carriage from the carriage beam and remove the nylon cord from around the upper and lower beam pulleys.

CAUTION: Do not remove the nylon cord from the pen carriage as this would require restringing the Y-axis. If this does occur, refer to paragraph 5-31 for restringing instructions.

(8) Remove the old wipers by drilling out the mounting rivets taking care not to enlarge the mounting holes.

(9) Rivet the new wipers to the pen carriages and reassemble.

b. X-AXIS WIPER. This assembly is located on the Y slider block at the upper end of the pen carriage beam. New wiper assemblies are Part No. A1937.

(1) Remove the platen, top trim strip, and rear cover.

(2) Tape the X-axis drive cables to pulleys C and J (figure 5-17) to prevent loss of cabling during succeeding steps.

(3) Using an Allen wrench, loosen the set screw fastening the Y-slider bar in place. This screw is located just above Idler Pulley J.

(4) Move the Y-slider bar out the right side of the recorder sufficiently to allow removal of the X-axis wiper.

(5) Install the new wiper, leaving mounting screws slightly loose.

(6) Re-install the slider bar, carefully positioning the rollers on the track at the lower end of the carriage beam. Tighten set screw. The retaining tape may now be removed from the cabling.

(7) Position the wiper assembly so that one wiper contacts the resistance wire mandrel and the other the solid return wire. Move slider bar assembly so that wiper mount aligns with access hole in rear frame. Insert a thin shaft Phillips screwdriver through this hole to tighten mounting screws.

(8) Re-install the platen, trip strip, and cover.

5-20. MECHANICAL MAINTENANCE

5-21. DISASSEMBLY. Access to the various components of the recorder is attained as follows:

a. Remove the AC power cord.

b. For access to the servo amplifier, power supply chassis, X and Y servo motors, and reference supplies, remove four machine screws which fasten the back cover on the instrument. To remove a plug-in chassis, take out four machine screws and pull the unit directly upward from the frame. When replacing a chassis, be sure to align the connector plugs with the corresponding receptacles before fastening.

c. Although removing both amplifier chasses will afford some access to the mechanical drive mechanism, it may be reached more easily by removing the recording platen. Place the carriage as far right as possible, remove platen mounting screws, and slide platen off to the left. The vacuum connection and curve follower contact are separated automatically when the platen is removed. When replacing, tighten the mounting screws securely to reseat these connections.

d. Access to the function and range switches is obtained by removing the cover from the bottom of the control box.

5-22. PEN MAINTENANCE. Pen assemblies should be cleaned thoroughly every two to four weeks by soaking in alcohol or hot water. Clogging during operation may be cleared by one or a combination of the following steps:

a. Apply air pressure through ink filler hole with syringe.

b. Internally clean tip by inserting the stiff fine wire supplied in the accessory kit.

c. Soak pen assembly in alcohol or hot water.

5-23. ADJUSTMENT OF PEN MOUNT. Both pen mounts are held on the carriage beam by eccentrically mounted rollers. To adjust, loosen screws on the pen tip side of the mounts and adjust eccentrics with a stiff wire. Retighten screws.

5-24. ADJUSTMENT OF PEN CARRIAGE BEAM. If a vertical pen trace deviates from perpendicular when compared with correctly aligned paper grids, the carriage beam should be adjusted. Open the control box and loosen the two machine screws at the lower end of the beam. Manually move the beam in the indicated direction until parallel with paper grids. Retighten both screws.

5-25. REMOVAL OF PEN CARRIAGE BEAM. It is necessary to dismount the pen carriage beams for cleaning or replacing the Y-axes rebalance potentiometers, or for installing a new nylon drive cord.

a. REMOVAL OF Y_2 CARRIAGE BEAM.

(1) Remove pens from their respective mounting blocks.

(2) Remove top trim strip, fastened by two machine screws.

(3) Remove two machine screws "A" at the lower end of the pen carriage, figure 5-17. Remove the associated cover and scale depression spring "B".

(4) Lift off scale, being careful not to damage the Y_2 pen drop electromagnet which is still connected to the recorder.

(5) Remove machine screw "C" located just below the lower drive gear.

(6) Remove the two machine screws fastening the beam to the lower end of the mounting block.

(7) The Y_2 carriage beam may now be separated from the Y_1 beam but not removed from the recorder because of the balance potentiometer cable connections. Complete removal requires unsoldering of cable connections.

b. REMOVAL OF Y_1 CARRIAGE BEAM.

(1) The Y_2 carriage beam must first be removed (see paragraph a above).

(2) Remove one machine screw from the center of the beam at the lower end, and two machine screws "D" on either side at the top.

(3) The upper end of the beam is now held only by the nylon drive cord tension around the upper drive pulley. Disconnect the cord from the pulley, taking care not to damage potentiometer connections.

(4) Slide the beam upwards, separating it from the lower carriage track, and carefully invert to expose potentiometer for service.

(5) Complete removal of beam requires unsoldering potentiometer connections.

5-26. ADJUSTMENT OF GEAR MESH. Backlash of the servo gear drive system may be adjusted as follows:

a. Y_1 AXIS GEAR ADJUSTMENT.

(1) Remove the recording platen and back cover (see paragraph 5-22c).

(2) Loosen motor mount clamp screws.

(3) Rotate the motor assembly slightly, first in one direction and then in the other, while moving the pen carriage back and forth until motor pinion rotates freely with minimum backlash. Rotation of motor assembly will vary the mesh between motor pinion and clutch gear due to the eccentric mounting shoulder. A slight amount of backlash is desirable for optimum operation.

(4) Tighten motor mounting screws and recheck for optimum backlash.

b. Y_2 AXIS GEAR ADJUSTMENT.

(1) Remove the top trim strip.

(2) Loosen clamps holding motor to assembly and rotate motor until idler gear and clutch gear are disengaged.

(3) Slightly loosen screw on clutch gear and rotate the eccentric mounting to vary the mesh between the gear and the motor drive shaft. A slight amount of backlash is desirable for optimum operation.

(4) Tighten clutch screw and re-engage idler with clutch.

(5) Before tightening motor clamps, rotate the motor slightly in alternate directions while moving the pen bracket. The motor should rotate freely with a slight amount of backlash.

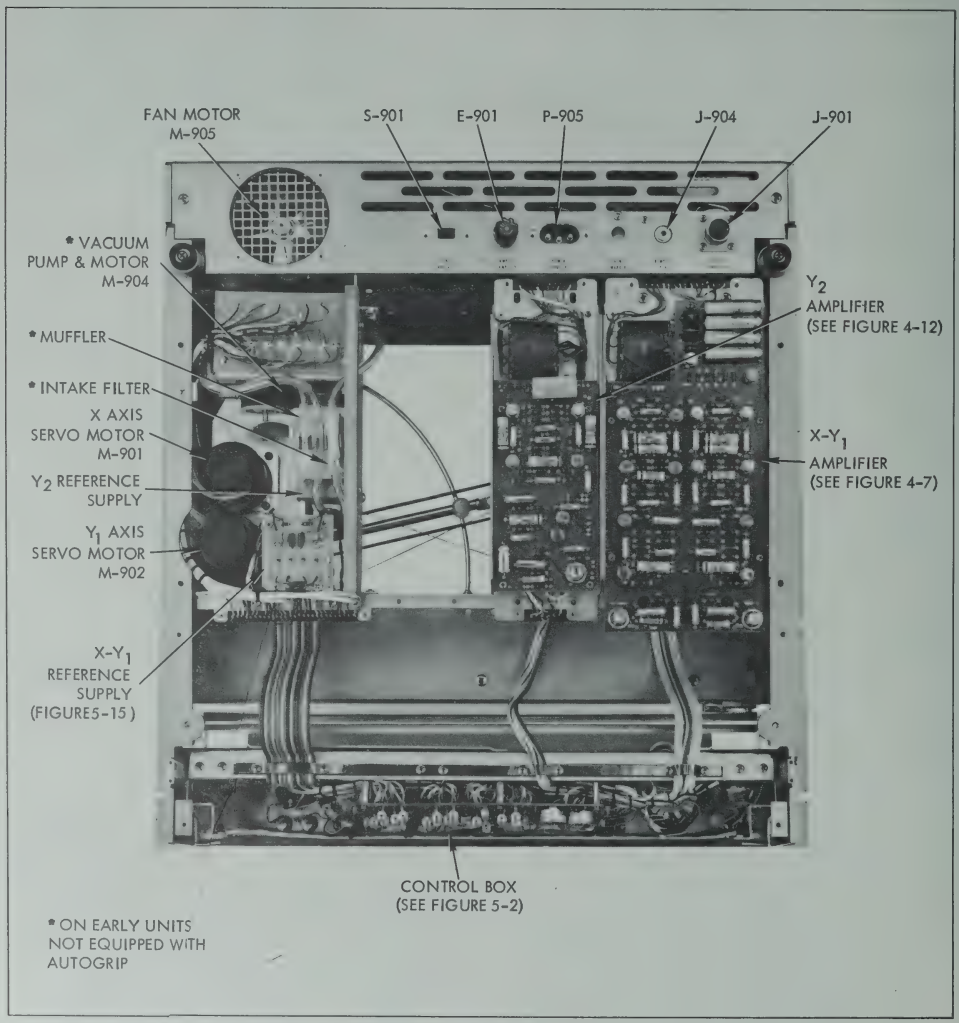


FIGURE 5-16. INSTRUMENT (BOTTOM VIEW)

(6) Tighten motor mounting screws and replace trim strip.

c. X-AXIS GEAR ADJUSTMENT.

(1) Use procedure similar to that for Y_1.

5-27. RESTRINGING INSTRUCTIONS. Restringing the X-axis necessitates removal of the recording platen and lower platen support bar. The Y_1 axis may be restrung by removal of only the platen. The Y_2 axis requires removal of only the upper trim strip.

5-28. MATERIALS REQUIRED. Before attempting to restring the recorder, the following materials should be available.

a. Approximately 8 feet of seven strand stringing cable, 1/64 inch diameter, Part No. 294-0001.

b. 4 Cable Crimps, Part No. 380-0115.

c. 1 Y_1 Nylon Cable Assembly, Part No. A-7856-1.

d. 1 Y_2 Nylon Cable Assembly, Part No. A-7856-6.

e. 2 Drive Belts, Part No. 209-0001-2.

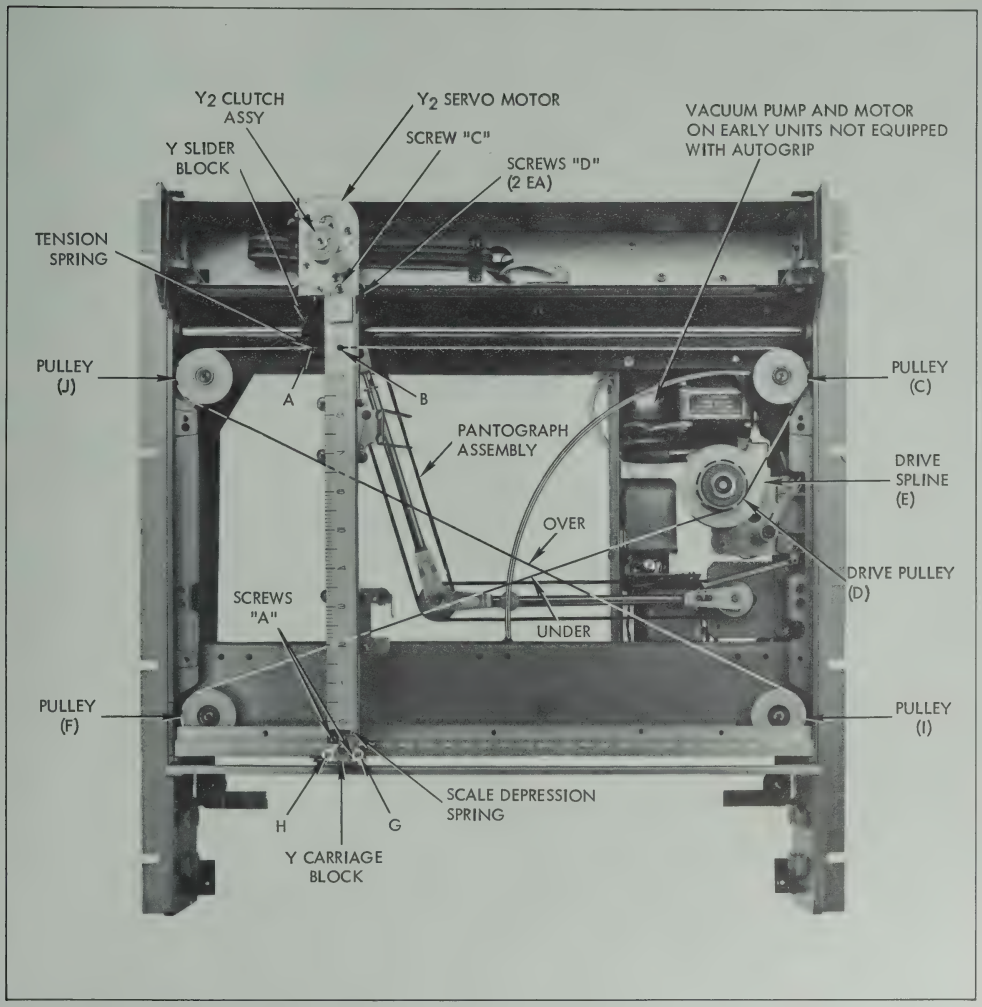


FIGURE 5-17. 2FRA WITHOUT PLATEN (FRONT VIEW)

5-29. X-AXIS RESTRINGING PROCEDURE.

a. Place the carriage assembly at a convenient location, securing with masking tape to prevent movement during subsequent steps.

b. Prepare a small loop approximately 1/4 inch in diameter in one end of a 50 inch length of cable. Clinch with a cable clamp.

c. Attach the prepared loop to the left arm of the tension spring, Point A, figure 5-17, and string cable CW to the right around pulley C to drive pulley D.

d. Wind three turns CW around the drive pulley D, proceeding from the outboard edge toward the inboard.

e. Continue CCW around pulley F to stud G on the bottom of the carriage assembly.

f. Making sure there is no crossover of the cable around pulley D, tighten and fasten at stud G with a cable clamp.

g. Prepare a small loop approximately 1/4 inch in diameter in one end of a second piece of cable 40 inches long and fasten loop with a cable clamp.

h. Attach the prepared loop to the right arm of the tension spring. Point B and string CCW around pulley J. Passing under the first cable, continue CW around idler pulley I to post H on the bottom of the carriage assembly.

i. Attach to stud G, tighten and fasten with a cable clamp.

5-30. Y_1, Y_2 AXES RESTRINGING PROCEDURE.

a. Replacement of the drive belt extending from the upper Y_1 carriage block to the center pulley of the pantograph assembly is self-explanatory.

b. Replacement of the drive belt extending from the Y_1 axis motor to the center pulley of the pantograph is accomplished as follows:

(1) Unhook the drive belt from the center pulley of the pantograph assembly.

(2) Separate the inner and outer halves of the arm connecting the two pulleys by sliding them apart. Do not lose internal spring.

c. Replacement of the nylon cord which drives the Y_1 pen carriage is accomplished as follows:

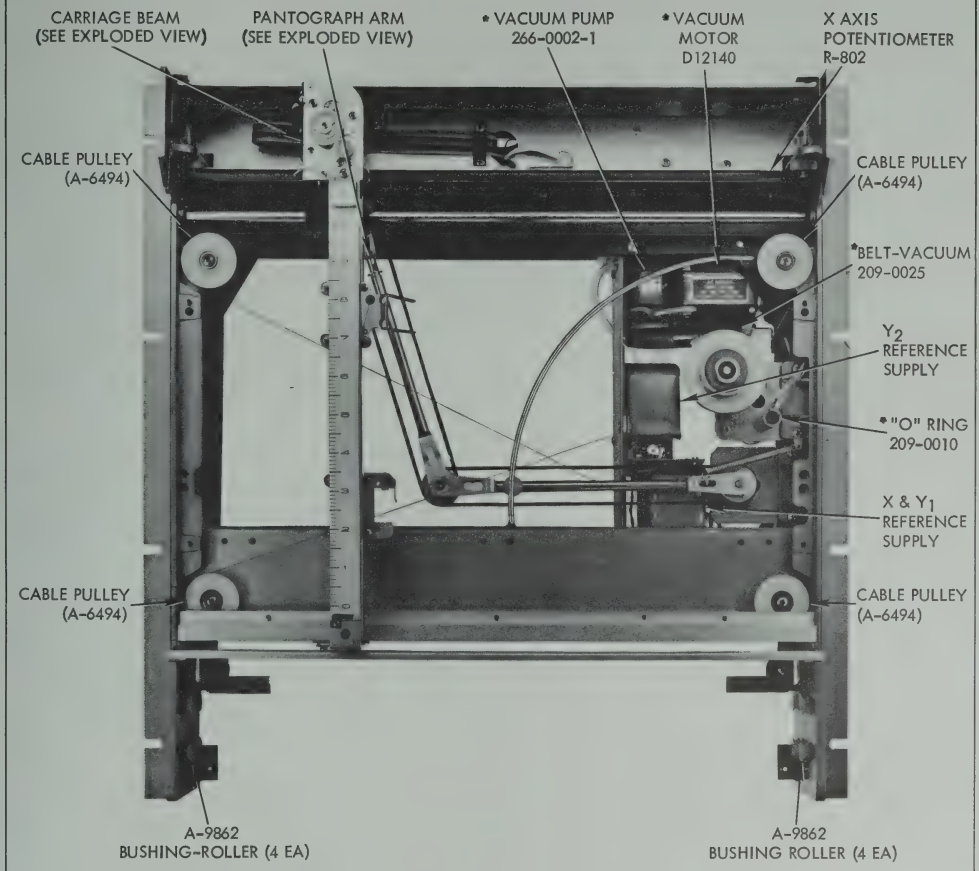
(1) Separate both the Y_2 and Y_1 carriage beams from recorder and from each other (see paragraph 5-25).

(2) Hook free end of tension spring to stud on Y_1 pen carriage. Spring should pull toward Y_1 drive pulley.

(3) Loop cord around the upper pulley and continue around the lower pulley back to the stud. Attach the hooked end of the nylon cord to the pen carriage stud.

(4) Reinstall the Y_1 carriage beam.

d. Replacement of the Y_2 nylon drive cord is accomplished in a manner identical to that for Y_1. When completed, reassemble Y_2 carriage beam.



*(ON MODELS WITHOUT AUTOGRIP)

FIGURE 5-18. 2FRA FRAME

SECTION VI
MODEL 2FR

6-1. DESCRIPTION

6-2. MODEL DIFFERENCES. Prior to Serial No. 79, the 2FRA was designated Model 2FR with several basic differences in specifications. With the exceptions outlined in this section, the 2FR may be installed, operated, and maintained as described for the Model 2FRA in the foregoing sections of this manual.

6-3. SPECIFICATION DIFFERENCES. All specifications for the 2FRA (Section 1-4) apply to the 2FR except the following:

RECORDING PLATEN: Accommodates standard 11" x 17" graph paper with 10" x 15" writing area. Built-in vacuum paper holddown.

DC INPUT RANGES: Ten ranges for each axis: 0.5, 1.0, 5, 10, 50 millivolts/division (inch), and 0.1, 0.5, 1.0, 5, 10 volts/division (inch). Potentiometric operation on most sensitive range by removal of straps on attenuator circuit (provides zero current drain at null).

INPUT RESISTANCE: 200,000 ohms/volt full scale (10") up to 1 volt/div; 2 megohms on all higher ranges.

6-4. OPERATION DIFFERENCES

6-5. INPUT DATA SIGNALS. Input terminals must be supplied with DC signals which are linear functions of the original information. The signals must vary at a rate within the response capabilities of the instrument (10 inches/sec in the X-axis; 20 inches/sec in either Y-axis) and have amplitudes within its scale ranges, 0 to 10 volts/div (inch).

6-6. POTENTIOMETRIC INPUT. For maximum sensitivity with minimum current drain, any axis may be converted to potentiometric input on the most sensitive range by removing straps on the input attenuator circuit (see figure 5-3). In this mode, the source impedance must be 50,000 ohms, or less.

6-7. OPERATING CONTROLS. Model 2FR uses slightly different nomenclature for the control functions:

a. VAC-PWR Switch:

(1) OFF-OFF - All power to instrument is turned off.

(2) OFF-ON - Vacuum system is off; all other parts of instrument are energized.

(3) ON-ON - All power is applied, including vacuum paper grip.

b. PEN-TIME Switch:

(1) STANDBY - Pen is raised off paper; chopper and motor reference phase are turned off.

(2) UP-RESET - All power is applied; pen remains raised for "dry runs". When in TIME mode, pen assumes a "start" position.

(3) DOWN-SWEEP - Pen is lowered to paper and input data will be recorded. When in TIME mode, sweep action is initiated automatically.

c. FUNCTION Switch: Same as Models 2FRA and 2FRAM.

6-8. OPERATION. Taking into consideration the differences outlined in paragraphs 6-1 through 6-7, the Model 2FR operating procedure is the same as described for Model 2FRA, paragraphs 3-13 through 3-24.

6-9. AMPLIFIER DIFFERENCES. The 2FR uses all-transistor amplifiers for each axis. Models 2FRA and 2FRAM have an added nuvistor to each servo amplifier to provide the extra gain required for the 1-megohm input feature.

Switch Range	Input Resistance (ohms/volt)	Full Scale (10") Current Drain (micro-amperes)	Full Scale (10") Input Resistance (ohms)
0.5 mv/div(inch)	200,000	5	1,000
1	200,000	5	2,000
5	200,000	5	10,000
10	200,000	5	20,000
50	200,000	5	100,000
0.1 v/div(inch)	200,000	5	200,000
0.5	200,000	5	1,000,000
1	200,000	5	2,000,000
5	40,000	25	2,000,000
10	20,000	50	2,000,000

FIGURE 6-1. INPUT CHART (2FR)

6-10. (2FR) 1ST & 2ND VOLTAGE AMPLIFIER. Diodes CR-501 and CR-502 provide overload protection for the first two transistors TR-501 and TR-502 which are connected in cascade as conventional voltage amplifiers. A major feedback path is from the emitter of TR-502 to the base of TR-501 through resistor R-504.

6-11. 2FR MAINTENANCE

6-12. VACUUM SYSTEM. The vacuum pump tends to collect dust, dirt, and ink. This may cause reduced efficiency or "freezing". Flushing is recommended at least every 100 hours, as follows:

a. Disconnect intake and exhaust line from pump without removing vacuum assembly.

b. Attach one end of a 10" tygon tube (Moseley Part No. 387-0025) to exhaust side of pump. Using the syringe from accessory kit, half-fill the tubing with Isoprapanol Alcohol (shellac thinner) and connect tube to pump intake. Start pump and circulate alcohol for 10 seconds. Stop pump, disconnect tube, feed into an absorbing cloth, restart pump to discharge alcohol. Repeat this procedure until alcohol remains clean.

c. Check all hose connections, lines, and filter for leakage or obstructions.

d. If all efforts fail to restore normal operation, return to factory for repairs or replacement.

e. Check V-belt of motor drive for wear or cracks.

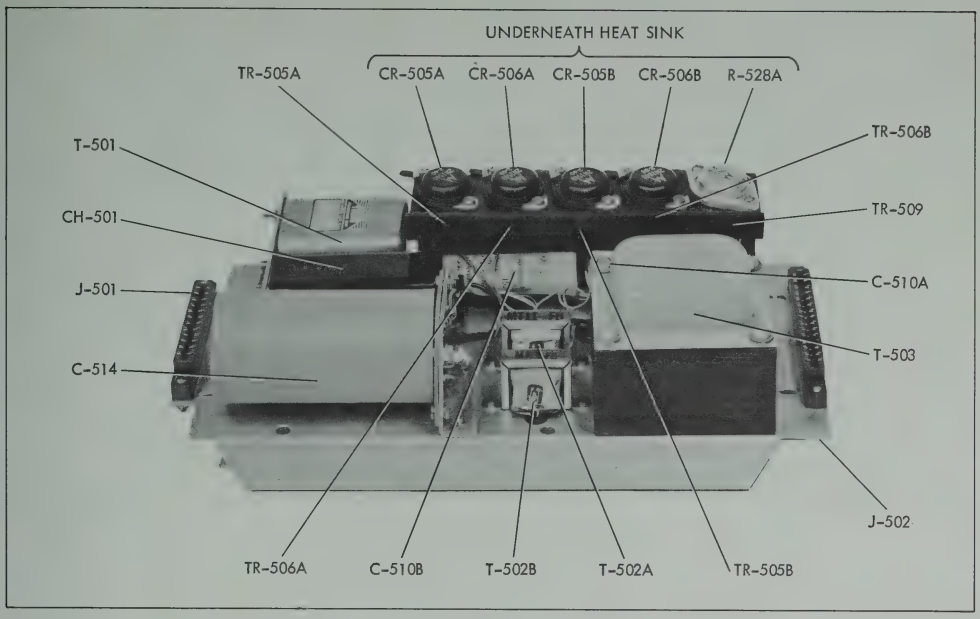


FIGURE 6-2. SERVO AMPLIFIERS AND POWER SUPPLY (TOP VIEW)

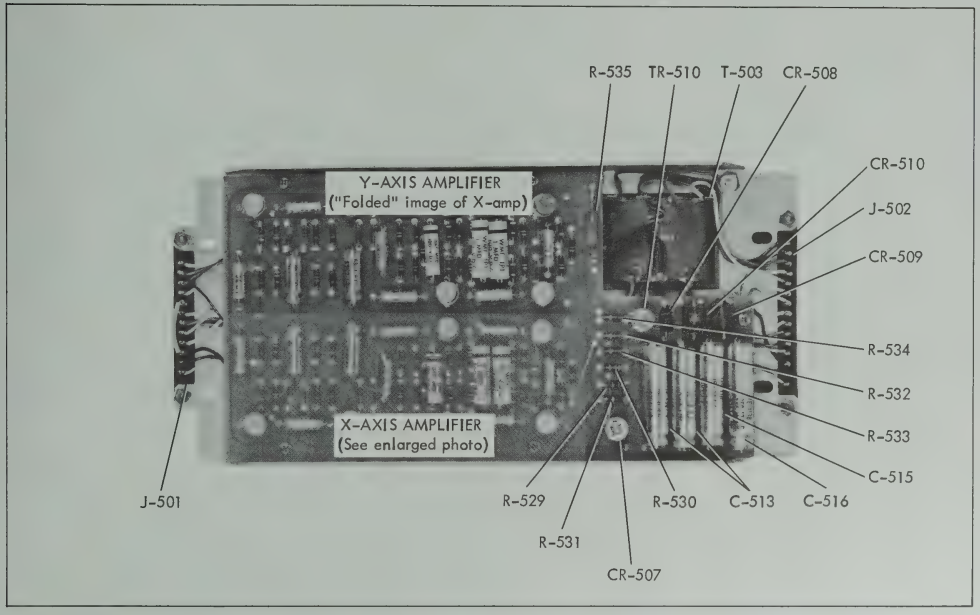


FIGURE 6-3. SERVO AMPLIFIERS AND POWER SUPPLY (BOTTOM VIEW)

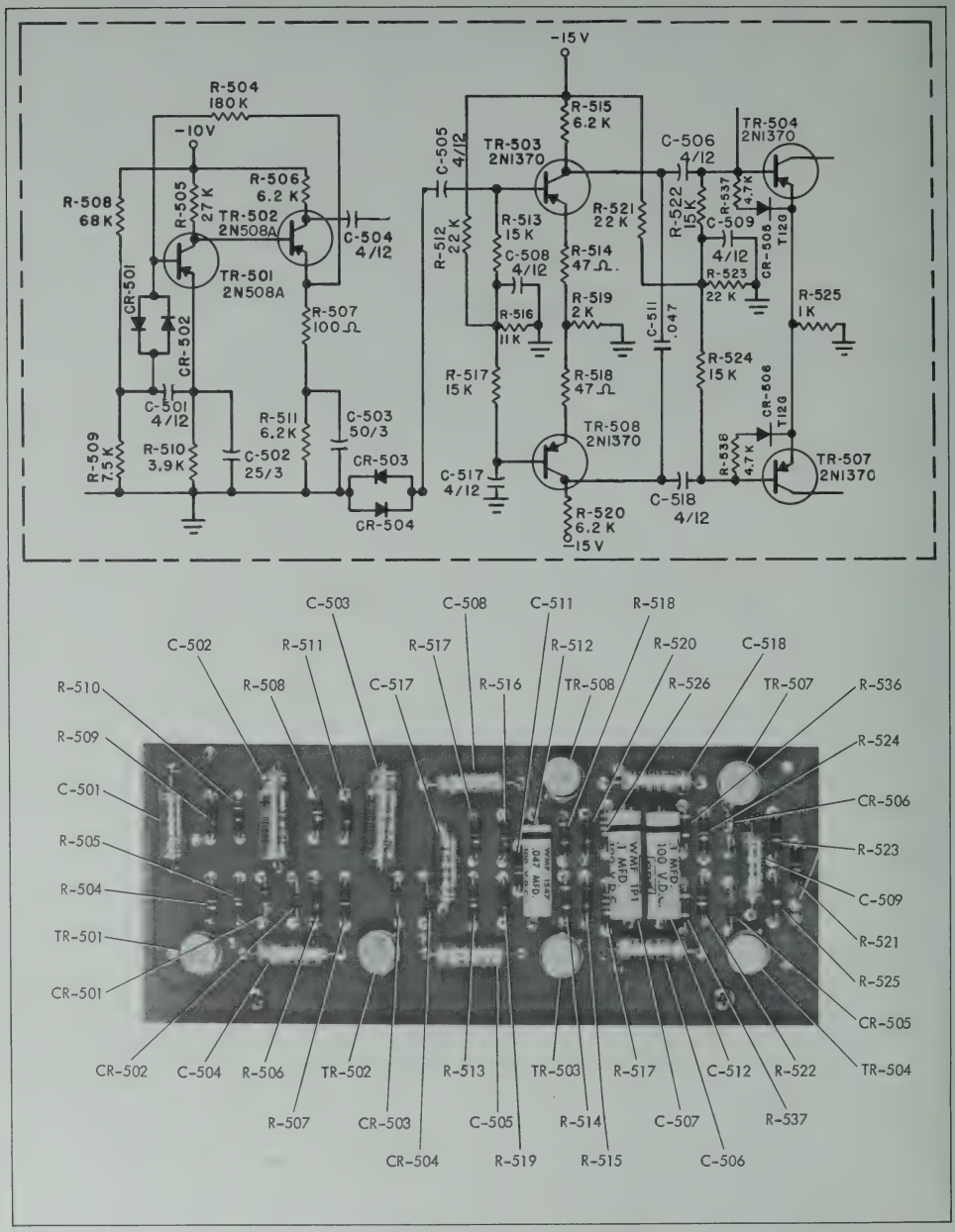
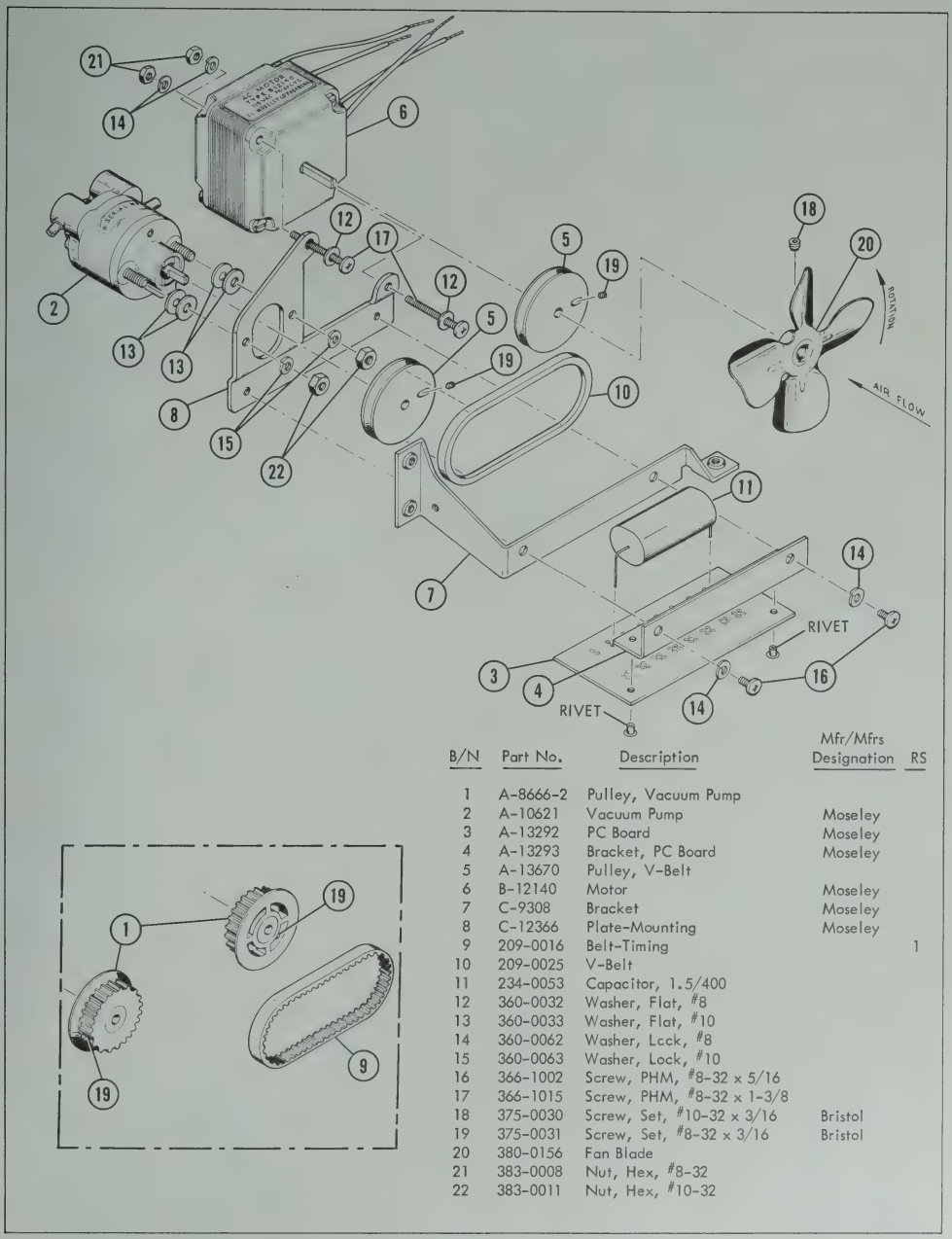


FIGURE 6-4. X-AXIS AMPLIFIER AND SCHEMATIC, ENLARGED VIEW

PARTS LIST FOR AMPLIFIERS AND POWER SUPPLY

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
C-501	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	2
C-502	231-0020	Capacitor, Electrolytic 25 mfd, 3v	Sprague TE1055	
C-503	231-0070	Capacitor, Electrolytic 50 mfd, 3v	Sprague TE1058	
C-504	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	
C-505	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	
C-506	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	
C-507	234-0035	Capacitor, Metalized 0.1 mfd, 100v	C-D WMF IPIE	
C-508	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	
C-509	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	
C-510	231-0107	Capacitor, Electrolytic 30 mfd, 150v	Aerovox E26D585	
C-511	234-0037	Capacitor, Metalized 0.047 mfd, 100v	C-D WMF 1547E	1
C-512	234-0035	Capacitor, Metalized 0.1 mfd, 100v	C-D WMF IPIE	1
C-513	231-0087	Capacitor, Electrolytic 50 mfd, 50v (2 in parallel)	Sprague TE1307	
C-514	231-0067	Capacitor, Electrolytic 1500 mfd, 50v	Mallory WP068	
C-515	231-0096	Capacitor, Electrolytic 250 mfd, 12v	Sprague TE1138	
C-516	231-0096	Capacitor, Electrolytic 250 mfd, 12v	Sprague TE1138	
C-517	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	
C-518	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	
CH-501	221-0007	Chopper	Stevens-Arnold BA-11-11	
CR-501	250-0031	Diode	Transitron	3
CR-502	250-0031	Diode	Transitron	
CR-503	250-0031	Diode	Transitron	
CR-504	250-0031	Diode	Transitron	
CR-505	252-0021	Diode	Transitron T-12G	1
CR-506	252-0021	Diode	Transitron T-12G	
CR-507	252-0025	Diode	Diodes Inc., DI-54	1
CR-508	252-0025	Diode	Diodes Inc., DI-54	
CR-509	250-0015	Diode, Zener	HP G31G12H	1
CR-510	252-0036	Diode	Solitron HC-30	1
CR-511	254-0008	Diode	Solitron SD-2	1
CR-512	254-0008	Diode	Solitron SD-2	
R-553	241-0234	Resistor, Composition 820 ohms, 2 W	Allen-Bradley	
R-537	241-0194	Resistor, Composition 4.7 K, 1/4 W, 10%	Allen-Bradley	1
T-501	204-0035	Transformer, Input	Triad G95038	1
T-502	204-0029	Transformer, Interstage	Triad 95005	1
T-503	202-0052	Transformer, Power	Triad 68944	1
TR-501	256-0055	Transistor	Texas Instr. 2N508A	1
TR-502	256-0055	Transistor	Texas Instr. 2N508A	
TR-503	256-0022	Transistor	Texas Instr. 2N1370	2
TR-504	256-0022	Transistor	Texas Instr. 2N1370	
TR-505	256-0053	Transistor	Delco 256-0053	2
TR-506	256-0053	Transistor	Delco 256-0053	
TR-507	256-0022	Transistor	Texas Instr. 2N1370	
TR-508	256-0022	Transistor	Texas Instr. 2N1370	
TR-509	256-0053	Transistor	Delco 256-0053	
TR-510	256-0022	Transistor	Texas Instr. 2N1370	
J501	316-0053	Connector	Amphenol 143-012-01	
J-502	316-0044	Connector	Amphenol 143-015-01	
R-504	241-0147	Resistor, Composition 180 K, 1/4 W, 5%	Allen-Bradley	
R-505	241-0221	Resistor, Composition 27 K, 1/4 W, 10%	Allen-Bradley	
R-506	241-0229	Resistor, Composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-507	241-0137	Resistor, Composition 100 K, 1/4 W, 10%	Allen-Bradley	
R-508	241-0235	Resistor, Composition 68 K, 1/4 W, 10%	Allen-Bradley	
R-509	241-0225	Resistor, Composition 7.5 K, 1/4 W, 5%	Allen-Bradley	
R-510A, B	241-0180	Resistor, Composition 3.9 K, 1/4 W, 10%	Allen-Bradley	
R-511A, B	241-0229	Resistor, Composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-5A, B	241-0149	Resistor, Composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-513A, B	241-0160	Resistor, Composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-514A, B	241-0136	Resistor, Composition 47 ohm, 1/4 W, 5%	Allen-Bradley	

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
R-515	241-0229	Resistor, Composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-516A, B	241-0227	Resistor, Composition 11 K, 1/4 W, 5%	Allen-Bradley	
R-517A, B	241-0160	Resistor, Composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-518A, B	241-0136	Resistor, Composition 47 ohm, 1/4 W, 10%	Allen-Bradley	
R-519A, B	241-0228	Resistor, Composition 2 K, 1/4 W, 5%	Allen-Bradley	
R-520A, B	241-0229	Resistor, Composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-521A, B	241-0149	Resistor, Composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-522A, B	241-0160	Resistor, Composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-523A, B	241-0149	Resistor, Composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-524A, B	241-0160	Resistor, Composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-525A, B	241-0145	Resistor, Composition 1 K, 1/4 W, 10%	Allen-Bradley	
R-526A, B	241-0181	Resistor, Composition 390 K, 1/4 W, 5%	Allen-Bradley	
R-527A, B	241-0181	Resistor, Composition 390 K, 1/4 W, 5%	Allen-Bradley	
R-528A, B	240-0052	Resistor, Composition 1 ohm, 3 W	Allen-Bradley	
R-529	241-0148	Resistor, Composition 3.3 K, 1/4 W, 10%	Allen-Bradley	
R-530	241-0148	Resistor, Composition 3.3 K, 1/4 W, 10%	Allen-Bradley	
R-531	241-0224	Resistor, Composition 8.2 K, 1/4 W, 10%	Allen-Bradley	
R-532	241-0218	Resistor, Composition 1.5 K, 1/4 W, 10%	Allen-Bradley	
R-533	241-0230	Resistor, Composition 82 ohms, 1/4 W, 10%	Allen-Bradley	



B/N	Part No.	Description	Mfr/Mfrs Designation	RS
1	A-8666-2	Pulley, Vacuum Pump		
2	A-10621	Vacuum Pump	Moseley	
3	A-13292	PC Board	Moseley	
4	A-13293	Bracket, PC Board	Moseley	
5	A-13670	Pulley, V-Belt		
6	B-12140	Motor	Moseley	
7	C-9308	Bracket	Moseley	
8	C-12366	Plate-Mounting	Moseley	
9	209-0016	Belt-Timing		1
10	209-0025	V-Belt		
11	234-0053	Capacitor, 1.5/400		
12	360-0032	Washer, Flat, #8		
13	360-0033	Washer, Flat, #10		
14	360-0062	Washer, Lock, #8		
15	360-0063	Washer, Lock, #10		
16	366-1002	Screw, PHM, #8-32 x 5/16		
17	366-1015	Screw, PHM, #8-32 x 1-3/8		
18	375-0030	Screw, Set, #10-32 x 3/16	Bristol	
19	375-0031	Screw, Set, #8-32 x 3/16	Bristol	
20	380-0156	Fan Blade		
21	383-0008	Nut, Hex, #8-32		
22	383-0011	Nut, Hex, #10-32		

FIGURE 6-5. VACUUM PUMP (EXPLODED VIEW)

WAVEFORM NOTES

The waveforms on the schematics were taken with a Hewlett-Packard Model 130C oscilloscope, of a 2FR recorder of known quality. Test points may be made accessible by removing the platen.

To obtain error signal for TP-1, TP-2, TP-3, TP-4, TP-5, TP-7 and TP-8.

a. Manually move pen 1/2 of one sub division (1/20", 1.27 mm).

b. Note error signal on scope.

c. Using zero control suppress zero (set zero beyond graph limits) for same amplitude signal. This allows a constant error signal without manually holding pen off null.

TEST POINTS

TP-1 Photo (a) is taken at null; (b) is at 0.5% full scale off null.

TP-2 Same as TP-1.

TP-3 Same as TP-1.

TP-4 Same as TP-1.

TP-5 Same as TP-1.

TP-6 Servo at null.

TP-7 Same as TP-1.

TP-8 Same as TP-1.

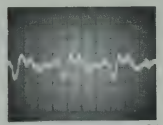
TP-9 Make measurements (with servo at null) across diode, i.e.; the (+) probe is connected to one side of the diode, the (-) probe to the other.

OSCILLOSCOPE SETTINGS

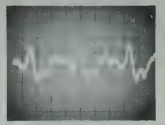
1. 5 ms/cm sweep speed.
2. Attenuator probe NOT used.
3. Observe scope polarity, negative side is connected to chassis ground.
4. All measurements except those taken at TP-9 are referenced to ground.

RECORDER SETTINGS

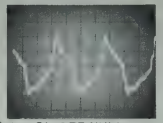
1. Recorder must be grounded.
2. Short input terminals.
3. Recorder must be in normal operating position, i.e., flat on table or horizontal in rack. Do not set on side as the weight of the carriage beam will cause an error signal.
4. Set the gain to 70% (mechanical) of its adjustable range.



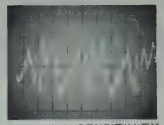
1. AT NULL SENSITIVITY .2MV/CM
TP-1



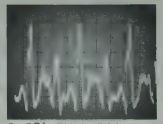
1. AT NULL SENSITIVITY 5MV/CM
TP-2



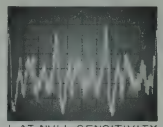
2..5% OFF NULL 20MV/CM



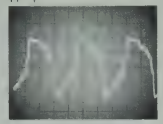
1. AT NULL SENSITIVITY 10MV/CM
TP-3



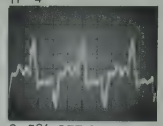
2..5% FULL SCALE OFF NULL 20MV/CM



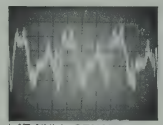
1. AT NULL SENSITIVITY .5V/CM
TP-4



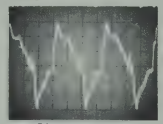
2..5% FULL SCALE OFF NULL .5MV/CM



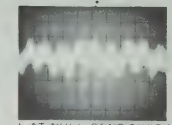
2..5% OFF SCALE 2V/CM



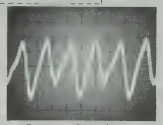
1. AT NULL SENSITIVITY 1V/CM
TP-5



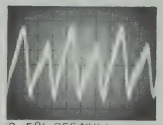
2..5% OFF NULL SENSITIVITY 5V/CM



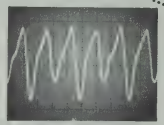
1. AT NULL SENSITIVITY 1MV/CM
TP-6



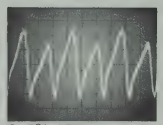
1. AT NULL 2MV/CM
TP-7



2..5% OFF NULL 5MV/CM



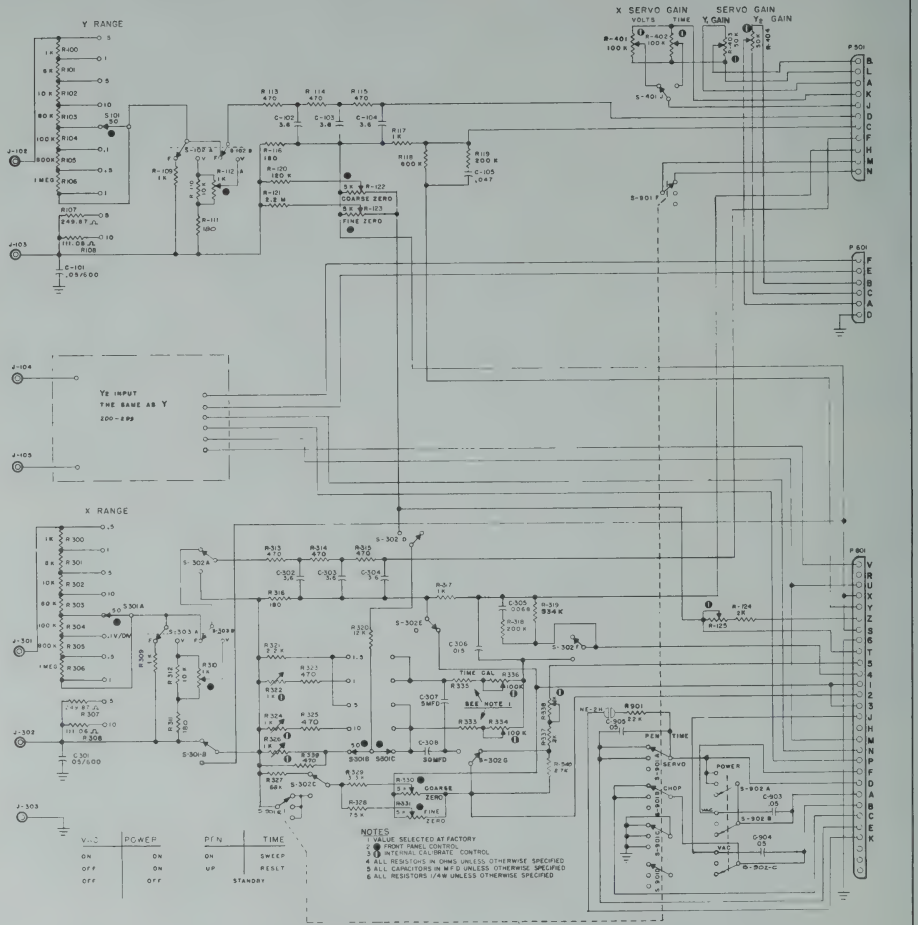
1. AT NULL SENSITIVITY .2V/CM
TP-8



2..5% OFF NULL SENSITIVITY .5V/CM

NOTES
1. ALL RESISTORS ARE 1/4 W

SCHEMATIC
TRANSISTOR SERVO AMPLIFIER
MODEL 2FR C-10651


Y RANGE
X RANGE
X SERVO GAIN
VOLTS
TIME
SERVO GAIN
Y GAIN
Y2 GAIN
Ye INPUT
THE SAME AS Y
200-299
P 501
P 801
J-102
J-103
J-104
J-105
J-301
J-302
J-303
S-101
S-102 A
S-102 B
S-102 C
S-102 D
S-301 A
S-301 B
S-302 A
S-302 B
S-302 C
S-302 D
S-302 E
S-302 F
S-302 G
S-303 A
S-303 B
S-401
S-801 A
S-801 B
S-801 C
S-801 D
S-801 E
S-801 F
S-902 A
S-902 B
R-100
R-101
R-102
R-103
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R-107
R-108
R-109
R-110
R-111
R-112 A
R-112 B
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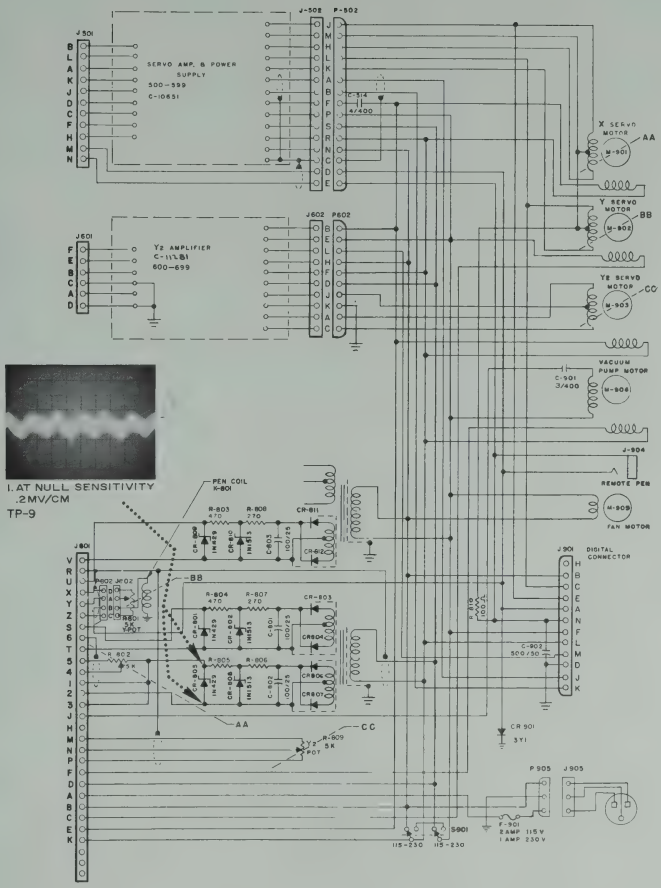
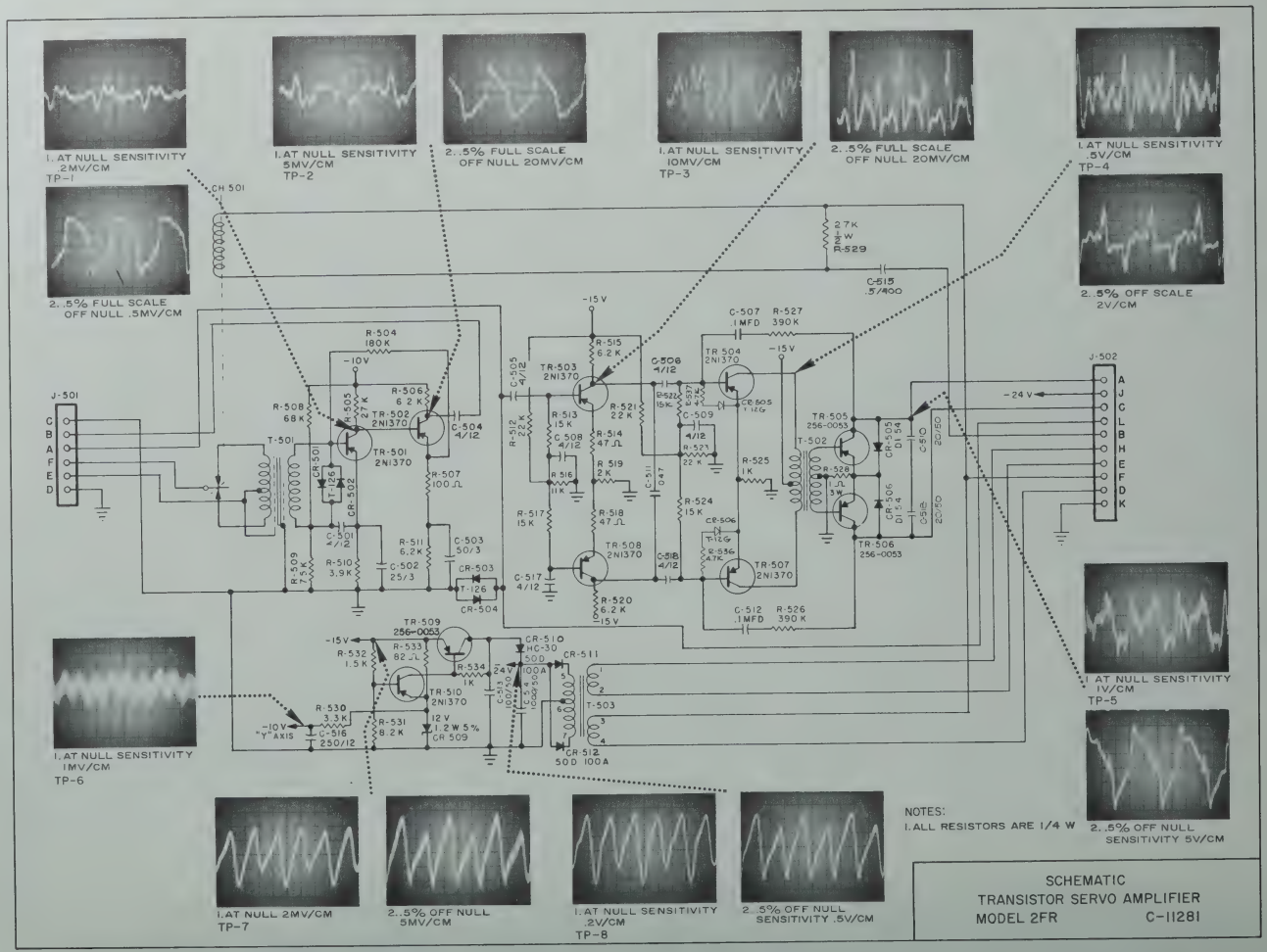
R-340
R-401
R-402
R-403
R-404
R-901
C-101
C-102
C-103
C-104
C-105
C-301
C-302
C-303
C-304
C-305
C-306
C-307
C-308
C-309
C-903
C-904
COARSE ZERO
FINE ZERO
TIME CAL
BEE NOTE 1
POWER
PEN
SERVO
CHOP
VAC
NOTES
1 VALUE SELECTED AT FACTORY
2 FRONT PANEL CONTROL
3 INTERNAL CALIBRATE CONTROL
4 ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
5 ALL CAPACITORS IN M F D UNLESS OTHERWISE SPECIFIED
6 ALL RESISTORS 1/4W UNLESS OTHERWISE SPECIFIED
V-C
POWER
PEN
TIME
ON
ON
SWEEP
OFF
ON
RESET
OFF
OFF
STANDBY



1. AT NULL SENSITIVITY .2MV/CM TP-9

SCHEMATIC
2FR
D-11414


1. AT NULL SENSITIVITY .2MV/CM TP-1
1. AT NULL SENSITIVITY 5MV/CM TP-2
2. .5% FULL SCALE OFF NULL 20MV/CM
1. AT NULL SENSITIVITY 10MV/CM TP-3
2. .5% FULL SCALE OFF NULL 20MV/CM
1. AT NULL SENSITIVITY 5V/CM TP-4
2. .5% OFF SCALE 2V/CM
2. .5% FULL SCALE OFF NULL .5MV/CM
CH 501
J-501
J-502
TR-501 2N1370
TR-502 2N1370
TR-503 2N1370
TR-504 2N1370
TR-505 256-0053
TR-506 256-0053
TR-507 2N1370
TR-508 2N1370
TR-509 256-0053
TR-510 2N1370
T-501
T-502
T-503
R-504 180K
R-505 2K
R-506 6.2K
R-507 100Ω
R-508 68K
R-509 75K
R-510 3.9K
R-511 6.2K
R-512 22K
R-513 15K
R-514 47Ω
R-515 6.2K
R-516 11K
R-517 15K
R-518 47Ω
R-519 2K
R-520 6.2K
R-521 22K
R-522 15K
R-523 22K
R-524 15K
R-525 1K
R-526 390K
R-527 390K
R-528 3W
R-529 2.7K ½W
R-530 3.3K
R-531 8.2K
R-532 1.5K
R-533 82Ω
R-534 1K
R-536 47K
C-501 4/12
C-502 25/3
C-503 50/3
C-504 4/12
C-505 4/12
C-506 4/12
C-507 .1MFD
C-508 4/12
C-509
C-510 20-50
C-511 .047
C-512 .1MFD
C-513 .002
C-515 .5/400
C-516 250/12
C-517 4/12
CR-501 DI-54
CR-502 T-125
CR-503 T-126
CR-504
CR-505 DI-54
CR-506 T-126
CR-507
CR-508
CR-509 12V 1.2W 5%
CR-510 HC-30 50D
CR-511 100A
CR-512 50D 100A
-15V
-10V
-24V
-10V "Y" AXIS
1. AT NULL SENSITIVITY 1MV/CM TP-6
1. AT NULL SENSITIVITY 1V/CM TP-5
2. .5% OFF NULL SENSITIVITY 5V/CM
1. AT NULL 2MV/CM TP-7
2. .5% OFF NULL 5MV/CM
1. AT NULL SENSITIVITY .2V/CM TP-8
2. .5% OFF NULL SENSITIVITY .5V/CM
NOTES:
1. ALL RESISTORS ARE 1/4 W
SCHEMATIC
TRANSISTOR SERVO AMPLIFIER
MODEL 2FR C-11281

SECTION VII
PARTS LIST

MODEL 2FRA & 2FRAM PARTS LIST

7-1. RECOMMENDED SPARES. This section lists all components on the schematic and items with mortality experience. Recommended spare parts for maintaining the instrument for a one year period are designated in column RS.

7-2. ORDERING: When ordering parts, the instrument TYPE and complete serial number should be included with the description as given in this section. To order a part not listed, describe the item, its location, and function. Orders and inquiries should be placed with your area field office.

PARTS LIST CONTROL BOX AND MECHANICAL ASSEMBLY

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
C-101	234-0049	Capacitor, mylar .05 mfd/600 V	Cornell-Dubilier WMF6S5	1
C-102	234-0039	Capacitor, metallized mylar .015 mfd/200 V	Faradyne MFC153M	1
C-103	234-0037	Capacitor, mylar .047 mfd/100 V	Cornell-Dubilier WMF1S47E	1
C-201	234-0049	Capacitor, mylar .05 mfd/600 V	Cornell-Dubilier WMF6S5	1
C-202	234-0039	Capacitor, metallized mylar .015 mfd/200 V	Faradyne MFC153M	
C-203	234-0037	Capacitor, mylar .047 mfd/100 V	Cornell-Dubilier WMF1S47E	
C-301	234-0049	Capacitor, mylar .05 mfd/600 V	Cornell-Dubilier WMF6S5	
C-302	234-0039	Capacitor, metallized mylar .015 mfd/200 V	Faradyne MFC153M	
C-303	235-0003	Capacitor, tantalum 5 mfd/50 V	Fansteel PP5B50A1	2
C-304	235-0007	Capacitor, tantalum 30 mfd/6 V	Fansteel PP30B6A1	2
C-305	234-0037	Capacitor, metallized mylar .015 mfd/200 V	Faradyne MFC153M	
C-306	233-0043	Capacitor, mylar .05 mfd/400 V	Cornell-Dubilier WMF4S5	
C-514	234-0043	Capacitor, metallized mylar 4 mfd/400 V	Electron Products D4-405	
C-801	231-0066	Capacitor, electrolytic 100 mfd/25 V	Sprague TE-1211	
C-802	231-0066	Capacitor, electrolytic 100 mfd/25 V	Sprague TE-1211	1
C-803	231-0066	Capacitor, electrolytic 100 mfd/25 V	Sprague TE-1211	
C-901	234-0053	Capacitor, metallized mylar 1.5 mfd/400 V	Electrocube 210B1E155K	
C-902	231-0078	Capacitor, electrolytic 500 mfd/50 V	Sprague TVA-1315	
C-903	231-0078	Capacitor, electrolytic 500 mfd/50 V (if installed)	Sprague TVA-1315	1
CR-101	252-0028	Diode, zener	1N821	1
CR-201	252-0028	Diode, zener	1N821	1
CR-301	252-0028	Diode, zener	1N821	1
CR-801	252-0028	Diode, zener	Hoffman 1N429	2
CR-802	252-0017	Diode, zener	International-Rec. 1N1513	2
CR-803	252-0021	Diode	Transitron T12G	2
CR-804	252-0021	Diode	Transitron T12G	
CR-805	252-0028	Diode, zener	Hoffman 1N429	

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
CR-806	252-0021	Diode	Transitron T12G	
CR-807	252-0021	Diode	Transitron T12G	
CR-808	252-0017	Diode, zener	International-Rec. 1N1513	
CR-809	252-0028	Diode, zener	Hoffman 1N429	
CR-810	252-0017	Diode, zener	International-Rec. 1N1513	
CR-811	252-0021	Diode	Transitron T12G	
CR-812	252-0021	Diode	Transitron T12G	
CR-901	254-0001	Diode	International-Rec. 3Y1	1
CR-902	254-0001	Diode, Event Marker (if installed)	International-Rec. 3Y1	
F-901	331-0053	Fuse, 2 A, 230 V	Bussman 3PG	10
	331-0003	Fuse, 3 A, 115 V		
J-101	312-0024	Binding post - red	HP G10E	
J-102	312-0025	Binding post - black	HP G10F	
J-201	312-0024	Binding post - red	HP G10E	
J-202	312-0025	Binding post - black	HP G10F	
J-301	312-0024	Binding post - red	HP G10E	
J-302	312-0025	Binding post - black	HP G10F	
J-801	319-0034	Connector - Printed Circuit	Space Products EZ1-28-D	1
J-901	316-0038	Connector - Digital	Amphenol 165-12	
J-903		Connector, Event Marker (if installed)		
J-904	346-0026	Jack, phone - Remote pen	Switchcraft 41	1
J-905	296-0007	Cord, power - removable	Belden PH-151	1
			CS9941-PH-104 7.5	
K-801	A-6714	Electromagnet, pen coil	Moseley	2
M-901	A-10475	Motor, servo	Moseley	1
M-902	A-10475	Motor, servo	Moseley	
M-903	227-0022	Motor, servo	Daystrom Type 15	1
M-904	D-12140	Motor, vacuum	Moseley	2
M-905	226-0018	Motor, fan	Barber-Colman YAA 707-3	1
P-501	A-9247	Connector - Printed Circuit	Moseley	
P-502	A-10571	Connector - Printed Circuit	Moseley	
P-601	A-9247	Connector - Printed Circuit	Moseley	
P-602	A-10571	Connector - Printed Circuit	Moseley	
P-801	A-9246	Connector - Printed Circuit	Moseley	
P-905	319-0032	Receptacle, power	Tower H-1061JG	
PL-901	336-0035	Pilot light, NE-2H	Sloan 859-1A-6	2
R-101	243-0410	Resistor, precision ww 990 K, 0.1%	Cinema 410E	1
R-102	243-0411	Resistor, precision ww 9.9 K, 0.1%	Cinema 410E	1
R-103	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-104	243-0029	Resistor, precision ww 100 ohm, 0.1%	Cinema 410E	
R-105	236-0096	Resistor, variable 100 K	CTS 35820	
R-106	241-0194	Resistor, composition 4.7, 1/4 W, 10%	Allen-Bradley	
R-107	243-0148	Resistor, precision ww 500 ohm, 0.1%	Cinema 410E	
R-108	243-0148	Resistor, precision ww 500 ohm, 0.1%	Cinema 410E	
R-109	243-0088	Resistor, precision ww 4 K, 0.1%	Cinema 410E	
R-110	243-0075	Resistor, precision ww 5 K, 0.1%	Cinema 410E	
R-111	243-0427	Resistor, precision ww 500 ohm, 1%	Cinema 410E	
R-112	241-0239	Resistor, composition 220 K, 1/4 W, 10%	Allen-Bradley	
R-113	241-0276	Resistor, composition 620 K, 1/4 W, 5%	Allen-Bradley	
R-114	243-0334	Resistor, precision ww 390.6 K, 1%	Cinema 410E	
R-115	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-117	236-0053	Resistor, variable 2.5 K	Clarostat A-43-2500	
R-118	243-0412	Resistor, precision ww 1500 ohm, 1%	Cinema 410E	
R-119	236-0059	Resistor, variable 1 K	CTS BK12449	
R-120	243-0327	Resistor, precision ww 2 K, 1%	Cinema 410E	
R-121	243-0179	Resistor, precision ww 1 K, 1%	Cinema 410E	
R-122	241-0157	Resistor, composition 47 K, 1/4 W, 10%	Allen-Bradley	
R-123	241-0210	Resistor, composition 100 K, 1/4 W, 10%	Allen-Bradley	
R-124	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-125	236-0029	Resistor, variable 50 K	CTS 33883	1
R-201	243-0410	Resistor, precision ww 990 K, 0.1%	Cinema 410E	
R-202	243-0411	Resistor, precision ww 9.9 K, 0.1%	Cinema 410E	
R-203	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-204	243-0029	Resistor, precision ww 100 ohm, 0.1%	Cinema 410E	

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
R-205	236-0096	Resistor, variable 100 K	CTS 35820	1
R-206	241-0194	Resistor, composition 4.7 K, 1/4 W, 10%	Allen-Bradley	
R-207	243-0148	Resistor, precision ww 500 ohm, 0.1%	Cinema 410E	
R-208	243-0148	Resistor, precision ww 500 ohm, 0.1%	Cinema 410E	
R-209	243-0088	Resistor, precision ww 4 K, 0.1%	Cinema 410E	
R-210	243-0075	Resistor, precision ww 5 K, 0.1%	Cinema 410E	
R-211	243-0427	Resistor, precision ww 500 ohm, 1%	Cinema 410E	
R-212	241-0239	Resistor, composition 220 K, 1/4 W, 10%	Allen-Bradley	
R-213	241-0276	Resistor, composition 620 K, 1/4 W, 5%	Allen-Bradley	
R-214	243-0334	Resistor, precision 390.6 K, 1%	Cinema 410E	
R-215	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-217	236-0053	Resistor, variable 2.5 K	Clarostat A-43-2500	1
R-218	243-0412	Resistor, precision ww 1500 ohm, 1%	Cinema 410E	
R-219	236-0059	Resistor, variable 1 K	CTS BK12449	1
R-220	243-0327	Resistor, precision ww 2 K, 1%	Cinema 410E	
R-221	243-0179	Resistor, precision ww 1 K, 1%	Cinema 410E	
R-222	241-0157	Resistor, composition 47 K, 1/4 W, 10%	Allen-Bradley	
R-223	241-0210	Resistor, composition 100 K, 1/4 W, 10%	Allen-Bradley	
R-224	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-225	236-0029	Resistor, variable 50 K	CTS 33883	
R-301	243-0410	Resistor, precision ww 990 K, 0.1%	Cinema 410E	
R-302	243-0411	Resistor, precision ww 9.9 K, 0.1%	Cinema 410E	
R-303	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-304	243-0029	Resistor, precision ww 100 ohm, 0.1%	Cinema 410E	
R-305	236-0096	Resistor, variable 100 K	CTS 35820	
R-306	241-0194	Resistor, composition 4.7 K, 1/4 W, 10%	Allen-Bradley	
R-307	243-0148	Resistor, precision ww 500 ohm, 0.1%	Cinema 410E	
R-308	243-0427	Resistor, precision ww 500 ohm, 1%	Cinema 410E	
R-309	243-0088	Resistor, precision ww 4 K, 0.1%	Cinema 410E	
R-310	243-0075	Resistor, precision ww 5 K, 0.1%	Cinema 410E	
R-311	242-0121	Resistor, precision, carbon 26.7 K, 1/2 W, 1%	Aerovox OPSX 1/2	
R-312	241-0216	Resistor, composition 680 ohms, 1/4 W, 10%	Allen-Bradley	
R-313	236-0059	Resistor, variable 1 K	CTS BK12449	2
R-314	241-0177	Resistor, composition 2.2 K, 1/4 W, 10%	Allen-Bradley	
R-315	241-0216	Resistor, composition 680 ohms, 1/4 W, 10%	Allen-Bradley	
R-316	236-0059	Resistor, variable 1 K	CTS BK12449	
R-317	236-0070	Resistor, variable 500 ohm	CTS BR12448	1
R-318		Resistor (Value selected at factory)		
R-319		Resistor (Value selected at factory)		
R-320	236-0095	Resistor, variable 100 K	CTS 35820	
R-321	236-0095	Resistor, variable 100 K	CTS 35820	
R-322	241-0312	Resistor, composition 130 K, 1/4 W, 5%	Allen-Bradley	
R-323	241-0148	Resistor, composition 3.3 K, 1/4 W, 10%	Allen-Bradley	
R-324	236-0053	Resistor, variable 2.5 K	Clarostat A-43-2500	
R-325	241-0157	Resistor, composition 47 K, 1/4 W, 10%	Allen-Bradley	
R-327	243-0412	Resistor, precision ww 1500 ohm, 1%	Cinema 410E	
R-328	243-0412	Resistor, precision ww 1500 ohm, 1%	Cinema 410E	
R-329	243-0327	Resistor, precision ww 2 K, 1%	Cinema 410E	
R-330	236-0059	Resistor, variable 1 K	CTS BK12449	
R-331	241-0229	Resistor, composition 6.2 K, 1/4 W, 10%	Allen-Bradley	
R-332	243-0179	Resistor, precision ww 1 K, 1%	Cinema 410E	
R-333	241-0157	Resistor, composition 47 K, 1/4 W, 10%	Allen-Bradley	
R-334	241-0210	Resistor, composition 100 K, 1/4 W, 10%	Allen-Bradley	
R-335	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-336	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-337	243-0473	Resistor, precision ww 240 K, 1%	Cinema 410E	
R-338	243-0406	Resistor, precision ww 300 ohm, 1%	Cinema 410E	
R-339	236-0006	Resistor, variable 100 K	Centralab BAO 11-1133	
R-340	236-0006	Resistor, variable 100 K	Centralab BAO 11-1133	
R-801	A-6712	Resistor, variable 5 K (Y_1 axis balance)	Moseley	2
R-802	A-11451	Resistor, variable 5 K (X axis rebalance)	Moseley	2
R-803	241-0158	Resistor, composition 470 ohm, 1/2 W, 10%	Allen-Bradley	
R-804	241-0158	Resistor, composition 470 ohm, 1/2 W, 10%	Allen-Bradley	

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
R-805	241-0158	Resistor, composition 470 ohm, 1/2 W, 10%	Allen-Bradley	
R-806	241-0096	Resistor, composition 270 ohm, 1/2 W, 5%	Allen-Bradley	
R-807	241-0096	Resistor, composition 270 ohm, 1/2 W, 5%	Allen-Bradley	
R-808	241-0096	Resistor, composition 270 ohm, 1/2 W, 5%	Allen-Bradley	
R-809	A-6712	Resistor, variable 5 K (Y_2 axis balance)	Moseley	2
R-810	240-0020	Resistor, non-precision ww 100 ohm, 3 W	Sprague 242E-1015	1
R-901	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-902	240-0019	Resistor, power 50 ohm, 5 W (if installed)	Ohmite	1
S-101	262-0070	Switch, range, Y_1 axis	CTS	
S-103	261-0031	Switch, slide, fixed-variable	Muter 4603-T	2
S-201	262-0070	Switch, range, Y_2 axis	CTS	
S-203	261-0031	Switch, slide, fixed-variable	Muter 4603-T	
S-301	262-0069	Switch, range, X axis	CTS	1
S-302	262-0071	Switch, function, X axis	CTS	1
S-303	261-0031	Switch, slide, fixed-variable	Muter 4603-T	
S-401	262-0053	Switch, lever, Servo-Sweep	Switchcraft 6S-1931A	2
S-402	261-0035	Switch, toggle, Power-Vacuum	Carling IG282-72 X MOS2	2
S-903	261-0037	Switch, snap, Power Conversion	HP 3101-0033	1
T-801	204-0026	Transformer, reference	Topaz 00837	1
T-802	204-0026	Transformer, reference	Topaz 00837	1

For the Model 2FRAM (metric scaled), the following 18 resistors are substituted for those listed on the preceding pages.

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
R-107	243-0069	Resistor, precision, ww 750 ohm, 0.1%	Cinema 410E	1
R-109	243-0432	Resistor, precision, ww 3.75 K, 0.1%	Cinema 410E	1
R-110	243-0431	Resistor, precision, ww 7.5 K, 0.1%	Cinema 410E	1
R-122	241-0209	Resistor, composition, 33 K, 1/4 W, 10%	Allen-Bradley	
R-123	241-0147	Resistor, composition, 180 K, 1/4 W, 10%	Allen-Bradley	
R-124	241-0178	Resistor, composition, 300 K, 1/4 W, 10%	Allen-Bradley	
R-207	243-0069	Resistor, precision, ww 750 ohm, 0.1%	Cinema 410E	1
R-209	243-0432	Resistor, precision, ww 3.75 K, 0.1%	Cinema 410E	1
R-210	243-0431	Resistor, precision, ww 7.5 K, 0.1%	Cinema 410E	1
R-222	241-0209	Resistor, composition, 33 K, 1/4 W, 10%	Allen-Bradley	
R-223	241-0147	Resistor, composition, 180 K, 1/4 W, 10%	Allen-Bradley	
R-224	241-0178	Resistor, composition, 300 K, 1/4 W, 10%	Allen-Bradley	
R-307	243-0069	Resistor, precision, ww 750 ohm, 0.1%	Cinema 410E	
R-309	243-0432	Resistor, precision, ww 3.75 K, 0.1%	Cinema 410E	
R-310	243-0431	Resistor, precision, ww 7.5 K, 0.1%	Cinema 410E	
R-333	241-0209	Resistor, composition, 33 K, 1/4 W, 10%	Allen-Bradley	
R-334	241-0147	Resistor, composition, 180 K, 1/4 W, 10%	Allen-Bradley	
R-335	241-0178	Resistor, composition, 300 K, 1/4 W, 10%	Allen-Bradley	

PARTS LIST - X AND Y_1 AMPLIFIERS

P/N M-14304
(Refer to Schematic MC-11635)

C-501	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	1
C-502	231-0020	Capacitor, electrolytic 25 mfd/3 V	Sprague TE-1055	1
C-503	231-0020	Capacitor, electrolytic 25 mfd/3 V	Sprague TE-1055	1
C-504	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-505	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-506	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-507	234-0035	Capacitor, mylar .1 mfd/100 V	Cornell-Dubilier WMF1P1E	
C-508	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-509	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-510	231-0107	Capacitor, electrolytic 30 mfd/150 V	Aerovox E26D585	1

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
C-511	234-0037	Capacitor, mylar .047 mfd/100 V	Cornell-Dubilier WMF1S47E	
C-512	234-0035	Capacitor, mylar .1 mfd/100 V	Cornell-Dubilier WMF1P1E	
C-513	231-0087	Capacitor, electrolytic 50 mfd/50 V (2 in parallel)	Sprague TE-1307	1
C-514	231-0067	Capacitor, electrolytic 1500 mfd/50 V	Mallory WP068	1
C-515	231-0096	Capacitor, electrolytic 250 mfd/12 V	Sprague TE-1138	
C-516	231-0096	Capacitor, electrolytic 250 mfd/12 V	Sprague TE-1138	
C-517	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-518	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-519	231-0095	Capacitor, electrolytic 50 mfd/10 V	Sprague TE-1119	
C-520	231-0095	Capacitor, electrolytic 50 mfd/10 V	Sprague TE-1119	
C-521	233-0019	Capacitor, paper .0022 mfd/100 V	C-D Miniroc STM1D22	
C-522	235-0008	Capacitor, tantalum 30 mfd/6 V	Fansteel F115	
CH-501	221-0007	Chopper	Stevens-Arnold BA-11-11	1
CR-501	252-0027	Diode	International-Rec. 1N1594	2
CR-503	252-0021	Diode	Transitron T12G	
CR-504	252-0021	Diode	Transitron T12G	
CR-505	252-0021	Diode	Transitron T12G	
CR-506	252-0021	Diode	Transitron T12G	
CR-507	252-0025	Diode	Diodes, Inc. DI-54	4
CR-508	252-0025	Diode	Diodes, Inc. DI-54	
CR-509	250-0015	Diode, zener	HP #G-31G12H	2
CR-510	252-0036	Diode	Solitron HC30	2
CR-511	252-0038	Diode	Solitron SOD100A	2
CR-512	252-0038	Diode	Solitron SOD100A	
J-501	316-0053	Connector	Amphenol 143-012-01	
J-502	316-0044	Connector	Amphenol 143-015-01	
R-504	241-0157	Resistor, composition 47 K, 1/4 W, 10%	Allen-Bradley	
R-505	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-506	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-507	241-0137	Resistor, composition 100 ohm, 1/4 W, 5%	Allen-Bradley	
R-508	241-0159	Resistor, composition 30 K, 1/4 W, 5%	Allen-Bradley	
R-509	241-0229	Resistor, composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-510	241-0137	Resistor, composition 100 ohm, 1/4 W, 5%	Allen-Bradley	
R-511	241-0224	Resistor, composition 8.2 K, 1/4 W, 10%	Allen-Bradley	
R-512	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-513	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-514	241-0136	Resistor, composition 47 ohm, 1/4 W, 5%	Allen-Bradley	
R-515	241-0229	Resistor, composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-516	241-0227	Resistor, composition 11 K, 1/4 W, 5%	Allen-Bradley	
R-517	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-518	241-0136	Resistor, composition 47 ohm, 1/4 W, 5%	Allen-Bradley	
R-519	241-0228	Resistor, composition 2 K, 1/4 W, 5%	Allen-Bradley	
R-520	241-0229	Resistor, composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-521	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-522	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-523	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-524	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-525	241-0145	Resistor, composition 1 K, 1/4 W, 10%	Allen-Bradley	
R-526	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-527	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-528	240-0052	Resistor, power 1 ohm, 3 W	Allen-Bradley	
R-529	241-0148	Resistor, composition 3.3 K, 1/4 W, 10%	Allen-Bradley	
R-530	241-0148	Resistor, composition 3.3 K, 1/4 W, 10%	Allen-Bradley	
R-531	241-0224	Resistor, composition 8.2 K, 1/4 W, 10%	Allen-Bradley	
R-532	241-0218	Resistor, composition 1.5 K, 1/4 W, 10%	Allen-Bradley	
R-533	241-0230	Resistor, composition 82 ohm, 1/4 W, 10%	Allen-Bradley	
R-534	241-0145	Resistor, composition 1 K, 1/4 W, 10%	Allen-Bradley	
R-535	240-0020	Resistor, non-precision ww 100 ohm, 3 W	Sprague 242E-1015	
R-536	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-537	241-0194	Resistor, composition 4.7 K, 1/4 W, 10%	Allen-Bradley	
R-538	241-0194	Resistor, composition 4.7 K, 1/4 W, 10%	Allen-Bradley	
R-540	241-0144	Resistor, composition 820 K, 1/4 W, 10%	Allen-Bradley	

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
R-541	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-542	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-543	241-0147	Resistor, composition 180 K, 1/4 W, 5%	Allen-Bradley	
T-501	204-0037	Transformer, input	Triad G95113	1
T-502	204-0029	Transformer, interstage	Microtran MT11-FB	1
T-503	202-0052	Transformer, power	Triad #68944	1
TR-501	256-0022	Transistor	Texas Instr. 2N1370	2
TR-502	256-0022	Transistor	Texas Instr. 2N1370	
TR-503	256-0022	Transistor	Texas Instr. 2N1370	
TR-504	256-0022	Transistor	Texas Instr. 2N1370	
TR-505	256-0034	Transistor	Motorola 2N1540	2
TR-506	256-0034	Transistor	Motorola 2N1540	
TR-507	256-0022	Transistor	Texas Instr. 2N1370	
TR-508	256-0022	Transistor	Texas Instr. 2N1370	
TR-509	256-0032	Transistor	Motorola 2N555	2
TR-510	256-0022	Transistor	Texas Instr. 2N1370	
V-501	251-0030	Tube, vacuum, nuvistor	RCA 7586	4

PARTS LIST - Y_2 AMPLIFIER

P/N A-12124
(Refer to Schematic MC-12103)

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
C-501	233-0019	Capacitor, paper .0022 mfd/100 V	C-D Miniroc STM1D22	
C-502	235-0008	Capacitor, tantalum 30 mfd/6 V	Fansteel F-115	
C-503	234-0035	Capacitor, mylar .1 mfd/100 V	Cornell-Dubilier WMF1P1E	
C-504	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-505	231-0020	Capacitor, electrolytic 25 mfd/3 V	Sprague TE-1055	
C-506	231-0020	Capacitor, electrolytic 25 mfd/3 V	Sprague TE-1055	
C-507	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-508	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-509	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-510	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-511	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-512	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-513	234-0035	Capacitor, mylar .1 mfd/100 V	Cornell-Dubilier WMF1P1E	
C-514	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-515	234-0035	Capacitor, mylar .1 mfd/100 V	Cornell-Dubilier WMF1P1E	
C-516	234-0035	Capacitor, mylar .1 mfd/100 V	Cornell-Dubilier WMF1P1E	
C-517	234-0047	Capacitor, metallized mylar .5 mfd/400 V	Electrocube 210D1E504J	
C-518	231-0103	Capacitor, electrolytic 20 mfd/50 V	Sprague TE-1305	
C-519	231-0103	Capacitor, electrolytic 20 mfd/50 V	Sprague TE-1305	
C-520	231-0048	Capacitor, electrolytic 1000 mfd/50 V	Sprague TVL-1338	
C-521	231-0077	Capacitor, electrolytic 100 mfd/50 V	Sprague TVL-1317	
C-523	231-0095	Capacitor, electrolytic 50 mfd/10 V	Sprague TE-1119	
C-525	231-0096	Capacitor, electrolytic 250 mfd/12 V	Sprague TE-1138	
CH-501	221-0007	Chopper	Stevens-Arnold BA-11-11	
CR-501	252-0021	Diode	Transitron T12G	
CR-502	252-0021	Diode	Transitron T12G	
CR-503	252-0021	Diode	Transitron T12G	
CR-504	252-0021	Diode	Transitron T12G	
CR-505	250-0022	Diode	Unitrode UZ812	
CR-506	252-0025	Diode	Diodes, Inc. DI-54	
CR-507	252-0025	Diode	Diodes, Inc. DI-54	
CR-508	252-0036	Diode	Solitron HC30	
CR-509	252-0038	Diode	Solitron 50D100A	
CR-510	252-0038	Diode	Solitron 50D100A	
CR-511	250-0015	Diode, zener	HP G-31G12H	
J-601	316-0053	Connector	Amphenol 143-012-01	

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
J-602	316-0044	Connector	Amphenol 143-015-01	
R-501	241-0090	Resistor, composition 1 meg, 1/4 W, 10%	Allen-Bradley	
R-502	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-503	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-504	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-505	241-0159	Resistor, composition 30 K, 1/4 W, 5%	Allen-Bradley	
R-506	241-0137	Resistor, composition 100 ohm, 1/4 W, 5%	Allen-Bradley	
R-507	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-508	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-509	241-0157	Resistor, composition 47 K, 1/4 W, 10%	Allen-Bradley	
R-510	241-0224	Resistor, composition 8.2 K, 1/4 W, 10%	Allen-Bradley	
R-511	241-0137	Resistor, composition 100 ohm, 1/4 W, 5%	Allen-Bradley	
R-512	241-0229	Resistor, composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-513	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-514	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-515	241-0227	Resistor, composition 11 K, 1/4 W, 5%	Allen-Bradley	
R-516	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-517	241-0229	Resistor, composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-518	241-0136	Resistor, composition 47 ohm, 1/4 W, 5%	Allen-Bradley	
R-519	241-0228	Resistor, composition 2 K, 1/4 W, 5%	Allen-Bradley	
R-520	241-0136	Resistor, composition 47 ohm, 1/4 W, 5%	Allen-Bradley	
R-521	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-522	241-0229	Resistor, composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-523	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-524	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-525	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-526	241-0194	Resistor, composition 4.7 K, 1/4 W, 10%	Allen-Bradley	
R-527	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-528	241-0145	Resistor, composition 1 K, 1/4 W, 10%	Allen-Bradley	
R-529	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-530	241-0042	Resistor, composition 2.7 K, 1/2 W, 10%	Allen-Bradley	
R-531	240-0052	Resistor, power 1 ohm, 3 W	Allen-Bradley	
R-532	241-0145	Resistor, composition 1 K, 1/4 W, 10%	Allen-Bradley	
R-533	241-0230	Resistor, composition 82 ohm, 1/4 W, 10%	Allen-Bradley	
R-534	241-0218	Resistor, composition 1.5 K, 1/4 W, 10%	Allen-Bradley	
R-535	241-0224	Resistor, composition 8.2 K, 1/4 W, 10%	Allen-Bradley	
R-536	240-0062	Resistor, power 100 ohm, 5 W	Allen-Bradley	
R-537	241-0148	Resistor, composition 3.3 K, 1/4 W, 10%	Allen-Bradley	
R-538	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-540	241-0194	Resistor, composition 4.7 K, 1/4 W, 10%	Allen-Bradley	
T-501	204-0037	Transformer, input	Triad G95113	
T-502	204-0029	Transformer, interstage	Microtran MT11-FB	
T-503	202-0052	Transformer, power	Triad 68944	
TR-501	256-0022	Transistor	Texas Instr. 2N1370	
TR-502	256-0022	Transistor	Texas Instr. 2N1370	
TR-503	256-0022	Transistor	Texas Instr. 2N1370	
TR-504	256-0022	Transistor	Texas Instr. 2N1370	
TR-505	256-0053	Transistor, power	Delco	
TR-506	256-0053	Transistor, power	Delco	
TR-507	256-0022	Transistor	Texas Instr. 2N1370	
TR-508	256-0022	Transistor	Texas Instr. 2N1370	
TR-509	256-0053	Transistor, power	Delco	
TR-510	256-0022	Transistor	Texas Instr. 2N1370	
V-501	251-0030	Tube, vacuum, nuvistor	RCA 7586	

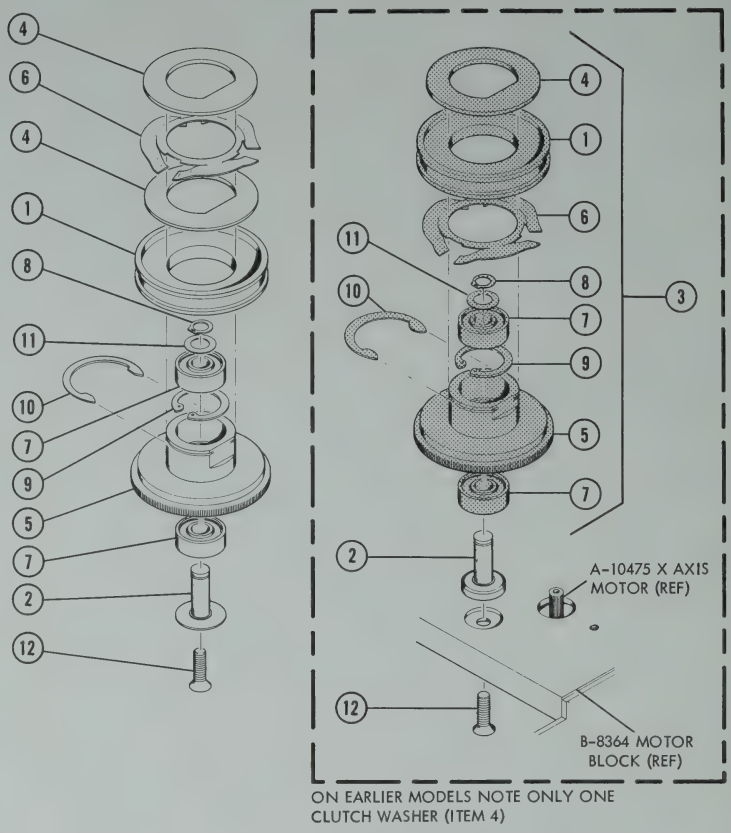
MISCELLANEOUS PARTS

Accessory Kit

A-9423	Syringe - modified (2 ea)	Moseley	2
B-10282	Pen Assembly (2 ea)	Moseley	2
331-0003	Fuse - 3 AG, 3A (5 ea)	Bussman 3PG	

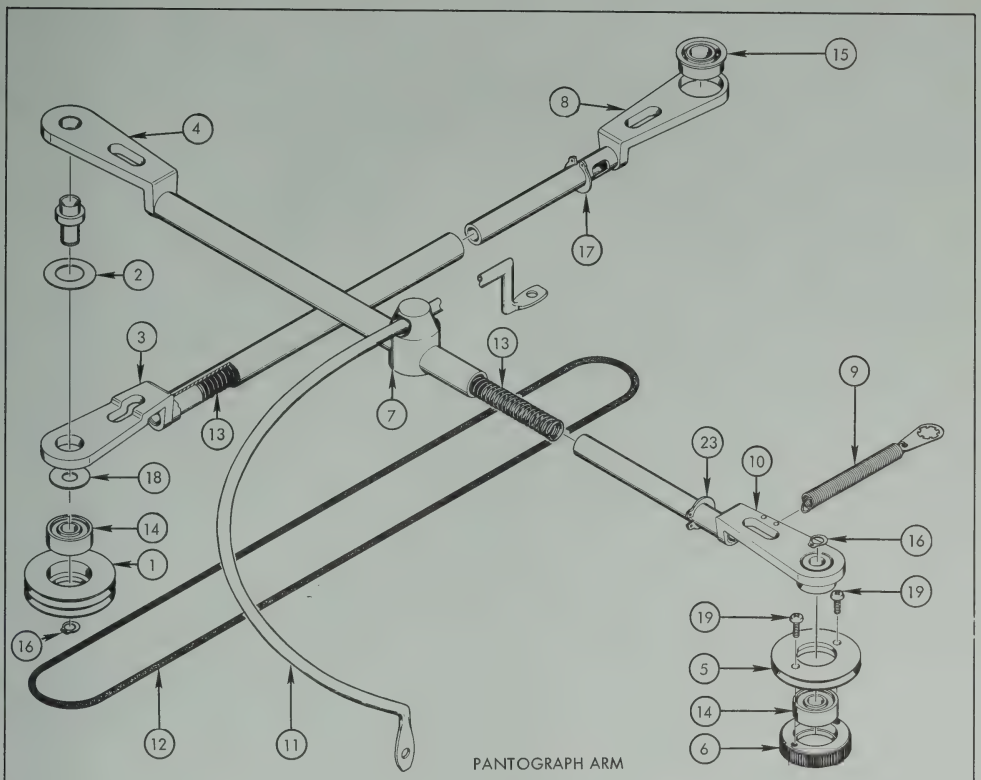
Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
Accessory Kit (Cont)				
	333-0005	Ink - Red	Esterline Angus	A/R
	333-0006	Ink - Green	Esterline Angus	A/R
	376-0005	Wrench	Bristol S-060	1
	376-0006	Wrench	Bristol S-076-4	1
	376-0007	Wrench	Bristol S-094	1
	376-0008	Wrench	Bristol S-110	1
	376-0009	Wrench	Bristol S-048-4	1
	376-0010	Wrench	Bristol S-114	1
	NPN	Wire - piano (1 ft.)		5'
Frame (See figure 5-1)				
	A-6494	Pulley - cable (4 ea)	Moseley	2
	A-6497	Pulley - motor (Y_1)	Moseley	2
	A-8683	Damper - inertia	Moseley	1
	A-9861	Roller - slide (6 ea)	Moseley	3
	A-9862	Bushing - roller (8 ea)	Moseley	
	A-10712	Outlet - exhaust	Moseley	
	A-10764	Tube - inlet and outlet	Moseley	
	A-10778	Cap - muffler (3 ea)	Moseley	
	A-15809	Assy - clutch "X" Axis	Moseley	
	A-5964	Sheave - "X" Clutch Assy	Moseley	
	A-10275	Washer - "X" Clutch Assy	Moseley	
	A-10728	Gear - "X" Clutch Assy	Moseley	
	355-0024	Spring - "X" Clutch Assy	Associated #S-10	
	356-0003	Bearing - "X" Clutch Assy	Fafnir 33KDD5	
	357-0016	Retaining Ring "X" Clutch Assy	Waldes N-5000-37	
	209-0025	Belt - vacuum "V" Type	A. Brown Co. .100X7.8	1
	A-10784-1	Pulley - vacuum pump	Moseley	
	A-10784-2	Pulley - vacuum pump	Moseley	
	A-10844-1	Foam - muffler	Moseley	4
	A-12747	Tube - muffler (2 ea)	Moseley	
	B-8944-1	Stop magnet (R.H.)	Moseley	
	B-8944-2	Stop magnet (L.H.)	Moseley	
	D-11483	Table - vacuum	Moseley	
	209-0004	"O" Ring	Minnesota Rubber & Gasket	3
	209-0008	"O" Ring	Parker 5427-7	3
	209-0016	Belt - vacuum (tooth type)	U.S. Rubber #80XL025	2
	A-10621	Vacuum pump	Gast #0330-V113A	1
	301-0017	Socket - nuvistor	Cinch #133-65-10-001	
	356-0003	Ball bearing	Fafnir #33KDD5	
	380-0128	Fan blade	Torrington #0-327-4	1
	A-6706	Slidewire "X" Axis (up to S/N 198)	Moseley	
Carriage and Associated Parts (See figures 5-3 thru 5-5)				
	A-2091	Bushing - eccentric (2 ea)	Moseley	1
	A-4457	Spring - pen	Moseley	3
	A-9723	Coil - pen	Moseley	
	A-9820	Spring - pen lift	Moseley	1
	A-13428	Spring - pen (modified)	Moseley	1
	355-0036	Spring - compression	Moseley	2
	356-0011	Ball bearing (4 ea)	Microtech #MR5632RPP	2
	A-7856-1	Assy - nylon cable	Moseley	
Pantograph Arm (See figure 5-2)				
	A-1950	Pulley	Moseley	
	A-9822	Spring	Moseley	
	355-0038	Spring (2 ea)	Moseley	

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
Pantograph Arm (See figure 5-2) (Cont)				
	356-0003	Ball bearing	Fafnir #33KDD5	
	356-0032	Ball bearing	New Hampshire #SFR188	
	357-0001	Retaining ring	Tru-Arc #5100-18	
	357-0024	Retaining ring (2 ea)	Waldes #5555-25MD	
	A-7099-1	Assy - Pantograph Arm	Moseley	
	A-8427-1	Assy - Pantograph Arm	Moseley	
	A-7734	Assy Slider Block Pantograph Arm	Moseley	
	A-9831	Assy "Y" Block Pantograph Arm (up to S/N 229)	Moseley	
	360-0114	Washer - Pantograph Arm	Seastrom #A362-33	
	A-16184	Assy "Y" Block Pantograph Arm (S/N 229 & up)		
Miscellaneous				
	228-0004	Graph paper	Gubelmann H-100150	
	228-0005	Graph paper	Gubelmann L-100150	
	391-0001	Slidewire Cleaner & Lubricant	Moseley	
	294-0001	Drive cable	McWhyte	
	380-0115	Cable Crimp		



B/N	Part No.	Description	Mfr/Mfrs Designation	RS
1	A-5964	Sheave-Drive	Moseley	
2	A-6488	Stud-Clutch	Moseley	
3	A-8956	Complete Clutch Assy	Moseley	1
4	A-10275	Washer-Clutch	Moseley	
5	B-10276	Gear-Clutch	Moseley	
6	355-0024	Spring	Associated Spring #S-10	
7	356-0003	Ball Bearing	MRC Type R3FF	
8	357-0001	Retaining Ring-External	Waldes Tru-Arc 5100-18	
9	357-0016	Retaining Ring-Internal	Waldes #N5000-50	
10	357-0021	Retaining Ring		
11	360-0090	Shim 0.005, 3/16 ID x 5/16 OD	Moseley	
12	367-0161	Screw, Flat Hd, 6-32		

FIGURE 7-1. X-AXIS SERVO DRIVE CLUTCH (EXPLODED VIEW)



B/N	Part No.	Description	Mfr/Mfrs Designation	RS
1	A-1950	Pulley	Moseley	
2	360-0114	Washer	Moseley	
3	A-7099-1	Pantograph Arm Assembly	Moseley	
4	A-8427-1	Pantograph Assembly	Moseley	
5	A-6497	Pulley, Motor	Moseley	1
6	A-6498	Gear, "Y" Motor	Moseley	1
7	A-6956	Slider, Pantograph Support	Moseley	1
8	A-7734	Slider Block Assembly	Moseley	
9	A-9822	Spring, Counterbalance	Moseley	1
10	A-9831	"Y" Block Assembly	Moseley	
11	C-6955	Slider Rod, Pantograph Support	Moseley	
12	209-0001-2	Belt	S.S. White 104	
13	355-0038	Spring, Pantograph		2
14	356-0003	Ball Bearing	MRC Type R3FF	2
15	356-0032	Ball Bearing	New Hampshire SFR 188	1
16	357-0001	Retaining Ring	Waldes, TRU-ARC-5100-18	
17	357-0024	Retaining Ring	Waldes, 5555-25MD	
18	360-0033	Washer		
19	366-0007	Screw, Binding Head, 2-56 x 1/4		

FIGURE 7-2. PANTOGRAPH ARM (EXPLODED VIEW)

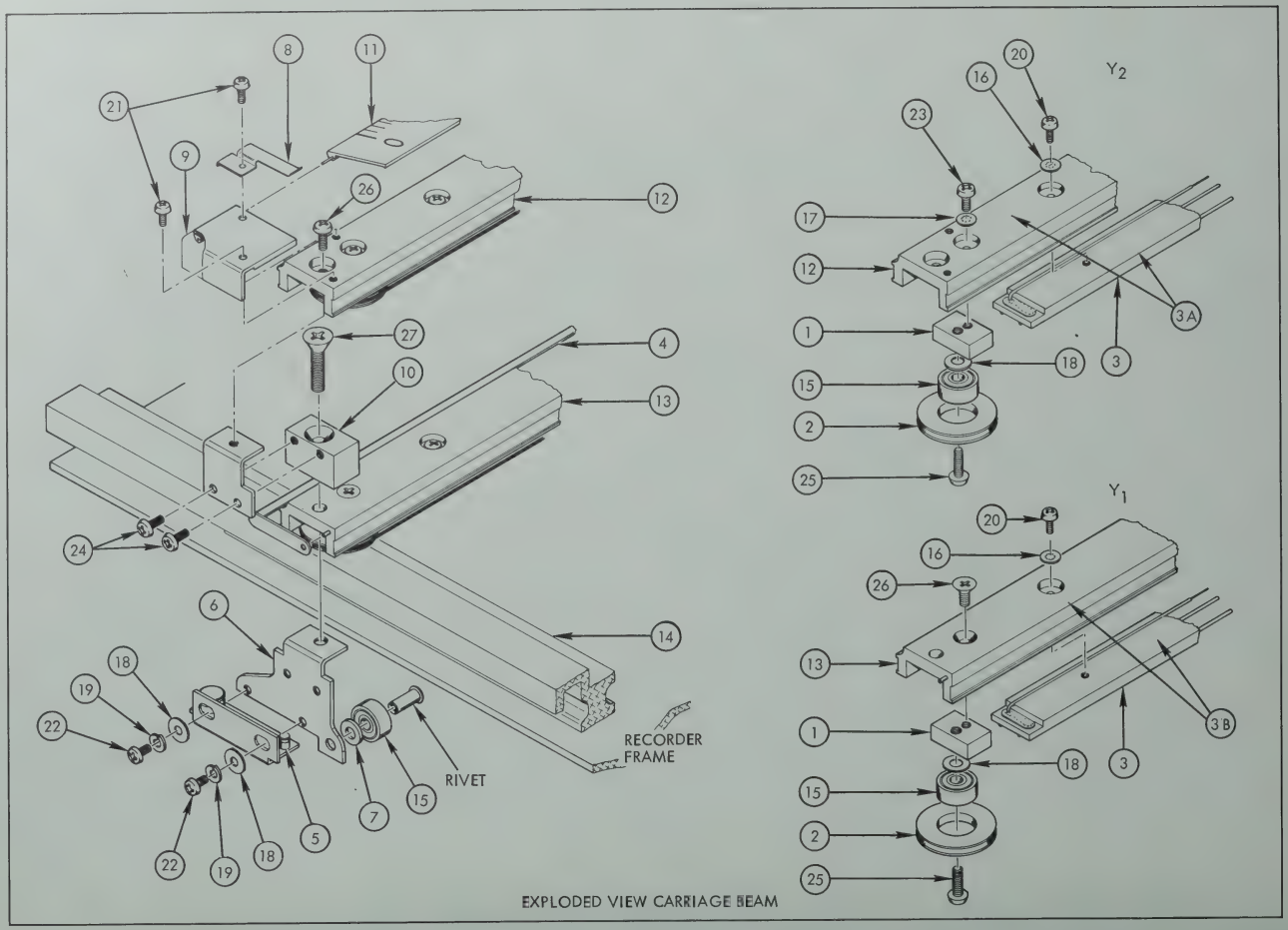


FIGURE 7-3. CARRIAGE ARM (EXPLODED VIEW) (Sheet 1 of 2)

B/N	Part No.	Description	Mfr/Mfrs Designation	RS
1	A-6455	Block, Spacer	Moseley	
2	A-6458	Pulley, Pen Cable	Moseley	
3	A-6712	Y-Slidewire Assembly, up to S/N 198	Moseley	1
3A	M-15206	Slidewire, (Y_2), S/N 198 and up	Moseley	1
3B	M-15724	Slidewire, (Y_1), S/N 198 and up	Moseley	1
4	A-6715	Pen Lift Assembly	Moseley	1
5	A-7090	Assembly Bracket Front Slider	Moseley	
6	A-7774	Slider Block, Lower	Moseley	
7	A-8340	Stud, Front Slider	Moseley	
8	A-8658	Stop, Pen Lift	Moseley	2
9	A-11349	Hinge, Lower (Y_2)	Moseley	
10	A-11370	Mount, Y_2 Arm	Moseley	
11	A-11612	Pen Scale Assembly	Moseley	
	A-13633	Scale and Solenoid (Metric)	Moseley	
12	B-11343	Track, Y_2 Arm, up to S/N 198	Moseley	
13	C-6445	Arm, Pen, up to S/N 198	Moseley	
14	C-6969	Edge, Table	Moseley	
15	356-0004	Ball Bearing	MRC	
16	360-0001	Washer, Lock, Internal Tooth #2	Type #R2FF	2
17	360-0003	Washer, Lock, Internal Tooth #4		
18	360-0030	Washer, Flat, #4		
19	360-0040	Washer, Lock, Split #4		
20	366-0001	Screw, Binder Head, 2-56 x 3/16		
21	366-0004	Screw, Binder Head, 2-56 x 3/16		
22	366-0413	Screw, Binder Head, 4-40 x 3/16		
23	366-0415	Screw, Binder Head, 4-40 x 5/16		
24	366-0432	Screw, Binder Head, 4-40 x 1/4		
25	366-0603	Screw, Binder Head, 5-40 x 5/16		
26	367-0102	Screw, Flat Head, 4-40 x 1/4		
27	367-0155	Screw, Flat Head, 4-40 x 9/16		
28	A-11376	Bracket - Y_2 - Lower	Moseley	

FIGURE 7-3. CARRIAGE ARM (EXPLODED VIEW) (Sheet 2 of 2)

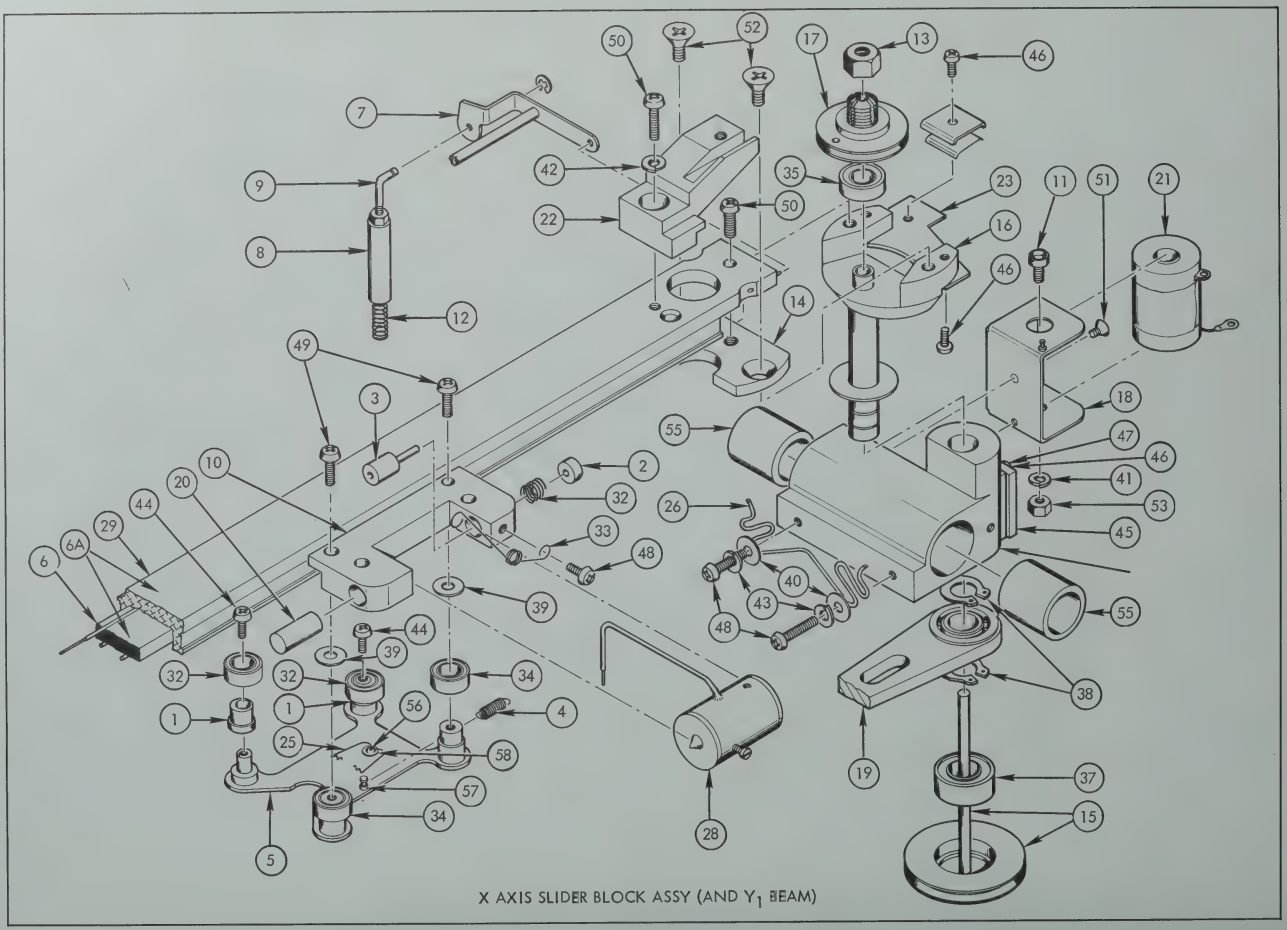


FIGURE 7-4. X-AXIS SLIDER BLOCK ASSEMBLY (AND Y_1 ARM) (Sheet 1 of 2)

B/N	Part No.	Description	Mfr/Mfrs Designation	RS
1	A-2091	Bushing, Eccentric	Moseley	2
2	A-2848	Cap, Spring	Moseley	
3	A-2850	Plunger	Moseley	2
4	A-5961	Spring, Cable	Moseley	2
5	A-8693	Pen Carriage Assembly, up to S/N 198	Moseley	
	M-15217	Pen Carriage Assembly, S/N 198 and up	Moseley	
6	A-6712	Y-axis Slidewire Assembly, up to S/N 198	Moseley	2
6A	M-15724	Y_1 Slidewire, S/N 198 and up	Moseley	
7	A-6715	Pen Lift Bail	Moseley	
8	A-7365	Plunger, Pen Lift	Moseley	1
9	A-7367-1	Arm, Plunger	Moseley	2
10	A-9112	Pen Block Assembly	Moseley	1
11	A-7449	Screw	Moseley	
12	A-7450	Spring, Plunger	Moseley	2
13	A-7642	Nut, Lock	Moseley	
14	A-7643	Plate, Channel	Moseley	
15	A-7647	Pulley and Shaft Assembly	Moseley	
16	A-7648	Channel Yoke and Shaft Assembly	Moseley	
17	A-7646	Pulley, Pen	Moseley	
18	A-7731	Bracket Solenoid Holder	Moseley	
19	A-8545-5	Hinge, Pantograph	Moseley	
20	A-9107	Plug-Pen Block	Moseley	1
21	A-9723	Pen Coil Assembly	Moseley	
22	A-11346	Block, Y_2 Arm	Moseley	
23	A-11380	Bracket, Clamp	Moseley	
25	B-6335	Contact, Wire, "Pot," up to S/N 198	Moseley	4
	M-14911	Contact, Wire, "Pot," S/N and up	Moseley	
26	B-6460	Bracket, Cable	Moseley	
28	B-10282	Pen Assembly	Moseley	2
29	C-6445	Arm, Pen	Moseley	2
30	C-7632	Block, Pen Slider	Moseley	
32	355-0036	Spring, Compression	Moseley	2
33	A-4457	Spring Pen Holddown	Moseley	
34	356-0011	Ball Bearing	Microtech #MR5632 RPP	2
35	356-0030	Ball Bearing	New Hampshire SR-166	
36	356-0032	Ball Bearing	New Hampshire SFR-188	2
37	356-0037	Ball Bearing	New Hampshire SR 1883	1
38	357-0024	Retaining Ring	Waldes #5555-25MD	2
39	360-0030	Washer, Flat, #4		
40	360-0036	Washer, Flat, #2		
41	360-0040	Washer, Lock, Split, #4		
42	360-0061	Washer, Lock, Split, #6		
43	360-0078	Washer, Lock, Split, #2		
44	366-0001	Screw, Binder Head, 2-56 x 3/16		
45	A-1937-X	Wiper, up to S/N 198	Moseley	
	M-15198	Wiper, S/N 198 and up	Moseley	
46	366-0002	Screw, Binder Head, 2-56 x 1/8		
47	360-0001	Lock Washer	Moseley	
48	366-0005	Screw, Binder Head, 2-56 x 1/4		
49	366-0825	Screw, Binder Head, 4-40 x 5/16		
50	366-0821	Screw, Binder Head, 6-32 x 7/16		
51	367-0003	Screw, Flat Head, 2-56 x 1/8		
52	367-0162	Screw, Flat Head, 6-32 x 1/4		
53	383-0005	Nut, Ratio #4		
55	385-0022	Bushing	Boston #B-68-4	
56	237-0002	Component Ilet, 1/16 x 3/32	Circon CE44	
57	312-0037	Terminal	Lerco 5090-B	
58	360-0035	Washer, Flat, Brass #0		

FIGURE 7-4. X-AXIS SLIDER BLOCK ASSEMBLY (AND Y_1 ARM) (Sheet 2 of 2)

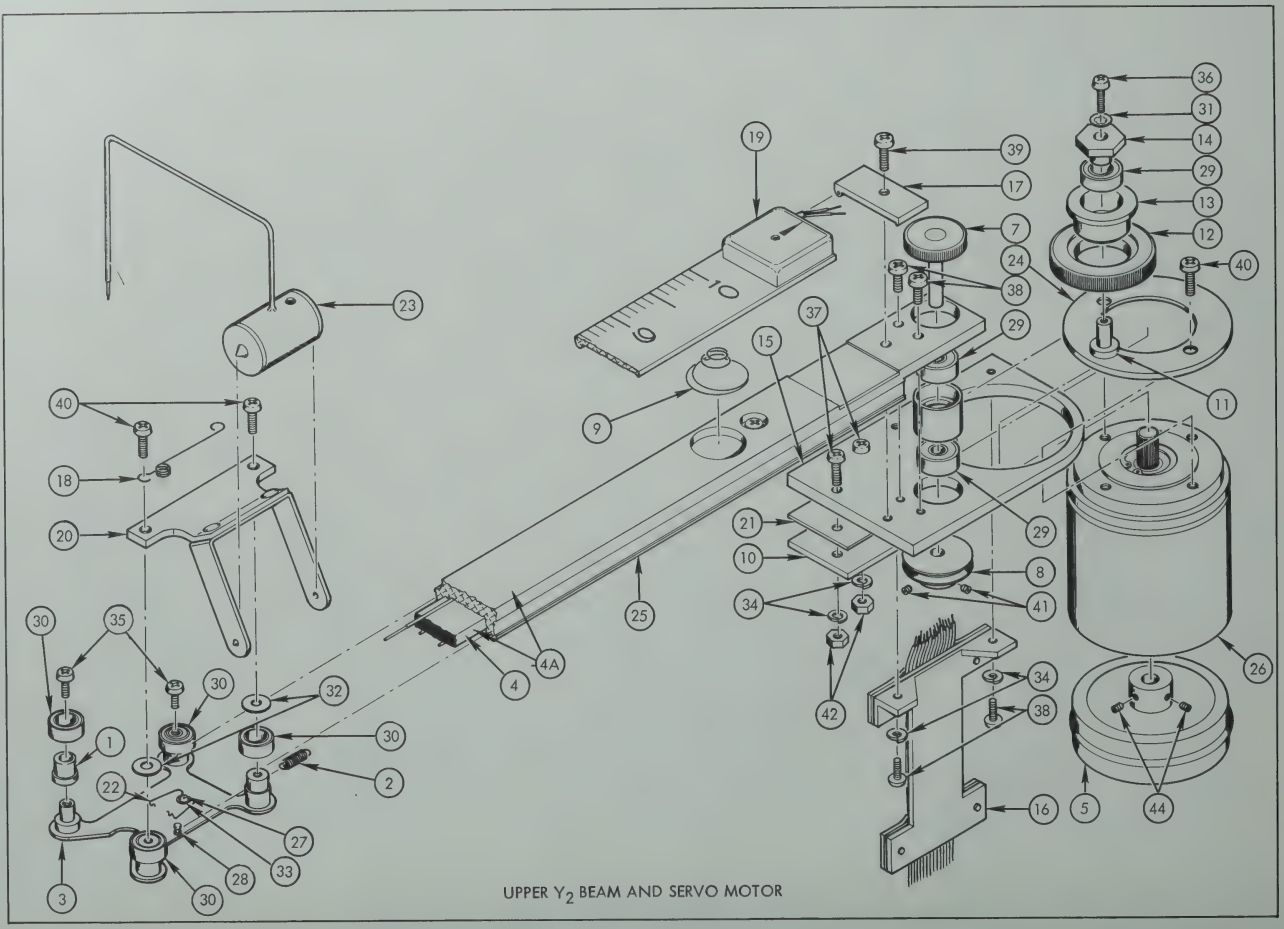
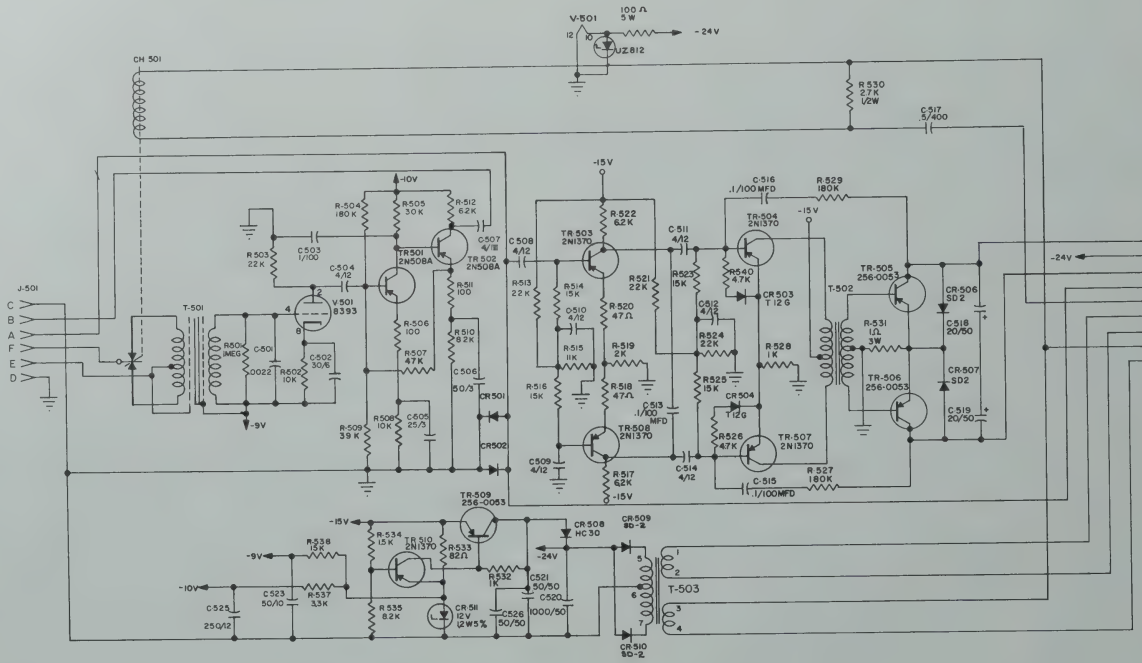


FIGURE 7-5. UPPER Y_2 ARM AND SERVO MOTOR (Sheet 1 of 2)

B/N	Part No.	Description	Mfr/Mfrs Designation	RS
1	A-2091	Bushing, Eccentric	Moseley	2
2	A-5961	Spring, Cable	Moseley	2
3	A-8693	Complete Pen Carriage Assembly, up to S/N 198	Moseley	
	M-15217	Complete Pen Carriage Assembly, S/N 198 and up	Moseley	
4	A-6712	Y-axis Slidewire, up to S/N 198	Moseley	1
4A	M-15206	Slidewire Assembly, S/N 198 and up	Moseley	
5	A-8683	Inertia, Damper	Moseley	1
6	A-9444	Housing, Bearing	Moseley	
7	A-9454	Drive Gear Y_2 Assembly	Moseley	
8	A-9498	Pulley, Upper	Moseley	
9	A-9820	Spring, Pen Lift	Moseley	2
10	A-10052	Terminal Board	Moseley	
11	A-11338	Shaft, Bearing	Moseley	
12	A-11339	Gear, Modified, up to S/N 168	Moseley	1
	A-14456	Gear-Idler, S/N 168 and up	Moseley	
13	A-11340	Enclosure, Bearing, up to S/N 168	Moseley	
	A-14456	Gear-Idler S/N 168 and up	Moseley	
14	A-11341	Bushing, Eccentric	Moseley	2
15	A-11344	Block, Motor Y_2		
16	A-11345	Bracket, Cable Guide	Moseley	
17	A-11350	Hinge, Upper	Moseley	
18	A-4457	Spring, Pen Holder		
19	A-11612	Solenoid, Pen Lift	Moseley	2
	A-13633	Solenoid, Pen Lift (Metric)	Moseley	
20	B-11377	Mount, Pen Holder	Moseley	
21	A-12224	Insulator, Terminal Board		
22	B-6335	Contact Wire, "Pot"	Moseley	3
	M-14911	Contact Wire, "Pot," S/N 198 and up	Moseley	
23	B-9373	Pen, Auxiliary	Moseley	1
24	B-9441	Retainer, Motor	Moseley	
25	B-11343	Track, Y_2 Arm, up to S/N 198	Moseley	
26	227-0022	Servo Motor, Modified	Daystrom	
27	237-0002	Component Eyelet	Circon CE44	
28	312-0037	Terminal	Lerco 5090-B	
29	356-0004	Ball Bearing	MRC Type #R2FF	
30	356-0011	Ball Bearing	Microtech MR5632RPP	2
31	360-0001	Washer, Lock Internal Tooth, #2		
32	360-0030	Washer, Flat, #4		
33	360-0035	Washer, Flat, Brass, #0		
34	360-0040	Washer, Lock, Split, #4		
35	366-0001	Screw, Binder Head, 2-56 x 3/16		
36	366-0007	Screw, Binder Head, 2-56 x 5/16		
37	366-0204	Screw, Binder Head, 3-48 x 3/8		
38	366-0407	Screw, Binder Head, 4-40 x 1/4		
39	366-0411	Screw, Binder Head, 4-40 x 1/2		
40	366-0415	Screw, Binder Head, 4-40 x 5/16		
41	375-0041	Set Screw, 2-56 x 1/4		
42	383-0010	Nut, Hex, 3-48 NC-2		

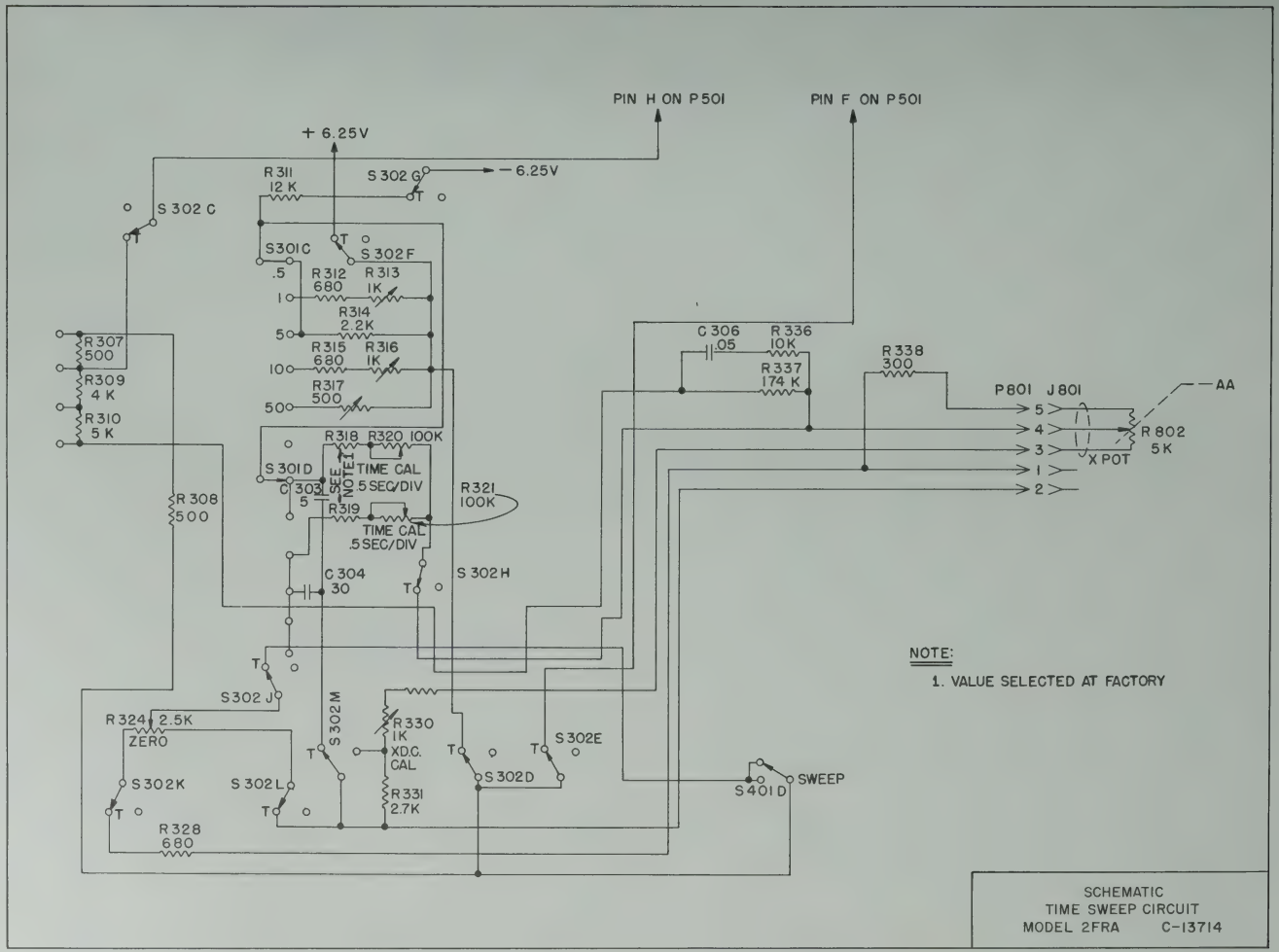
FIGURE 7-5. UPPER Y_2 ARM AND SERVO MOTOR (Sheet 2 of 2)

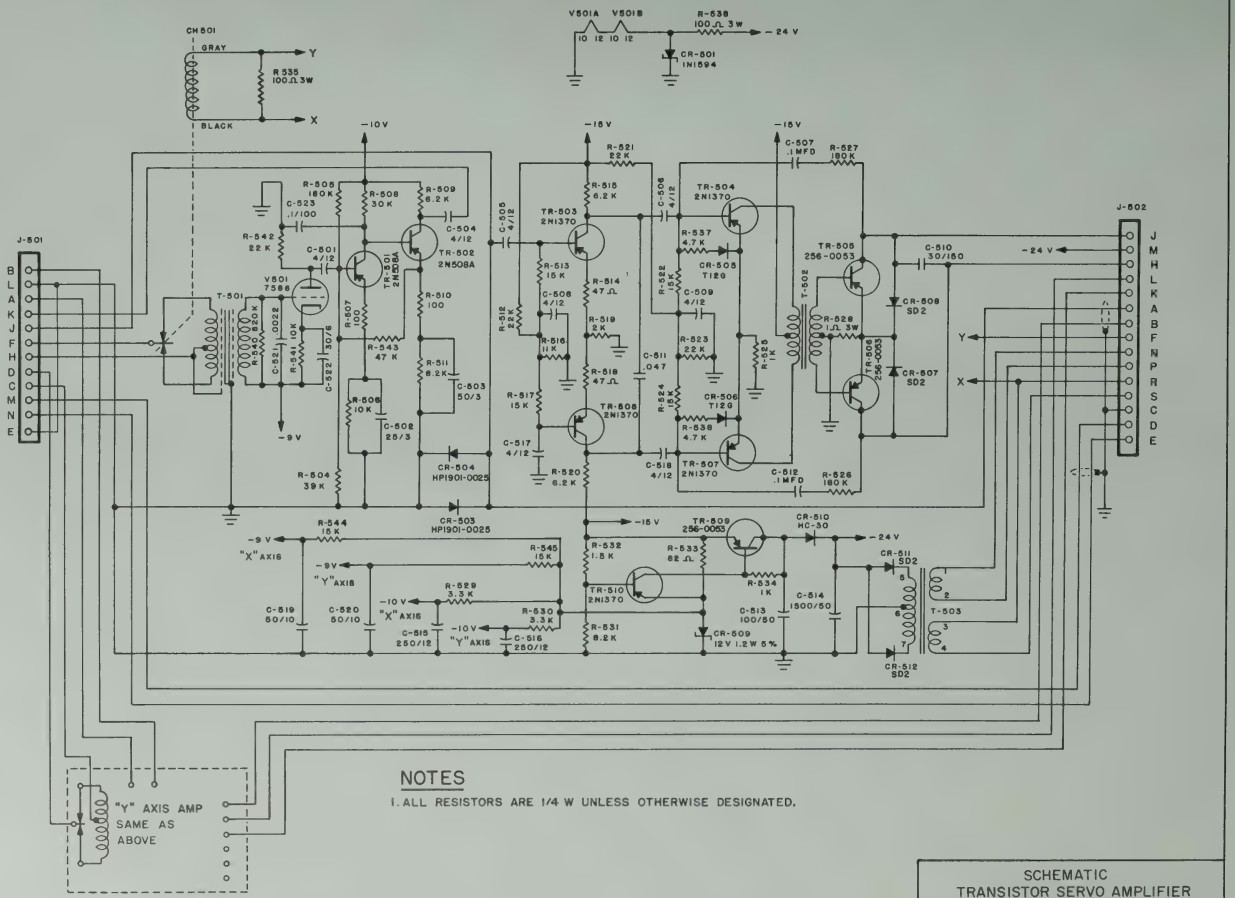


NOTES

ALL RESISTORS ARE 1/4 WATT UNLESS OTHERWISE NOTED

SCHEMATIC
TRANSISTOR SERVO AMPLIFIER
MODEL 2FRA C-12103

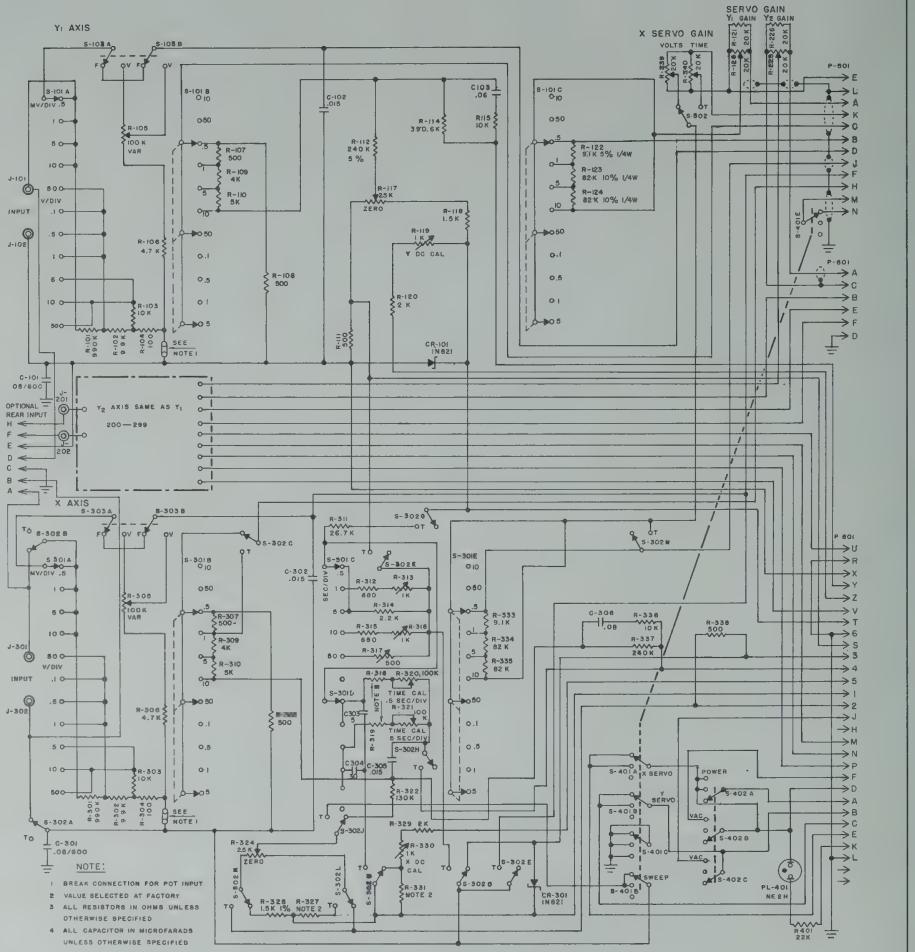

PIN H ON P501
PIN F ON P501
+ 6.25V
R311 12 K
S 302 G
- 6.25V
S 302 C
S301C
S 302 F
.5
1
5
10
50
R312 680
R313 1K
R314 2.2K
R315 680
R316 1K
R317 500
R307 500
R309 4 K
R310 5 K
R318
R320 100K
S 301D
C 303 5
SEE NOTE 1
TIME CAL .5 SEC/DIV
R319
R321 100K
TIME CAL .5SEC/DIV
R 308 500
C 304 30
S 302 H
S 302 J
R324 2.5K ZERO
S 302 M
R330 1K XDC. CAL
R331 2.7K
S 302 K
S 302 L
R328 680
S 302 D
S 302 E
S 401 D
SWEEP
C 306 .05
R 336 10K
R337 174 K
R 338 300
P801 J801
5
4
3
1
2
X POT
R 802 5K
AA
NOTE:
1. VALUE SELECTED AT FACTORY
SCHEMATIC
TIME SWEEP CIRCUIT
MODEL 2FRA C-13714

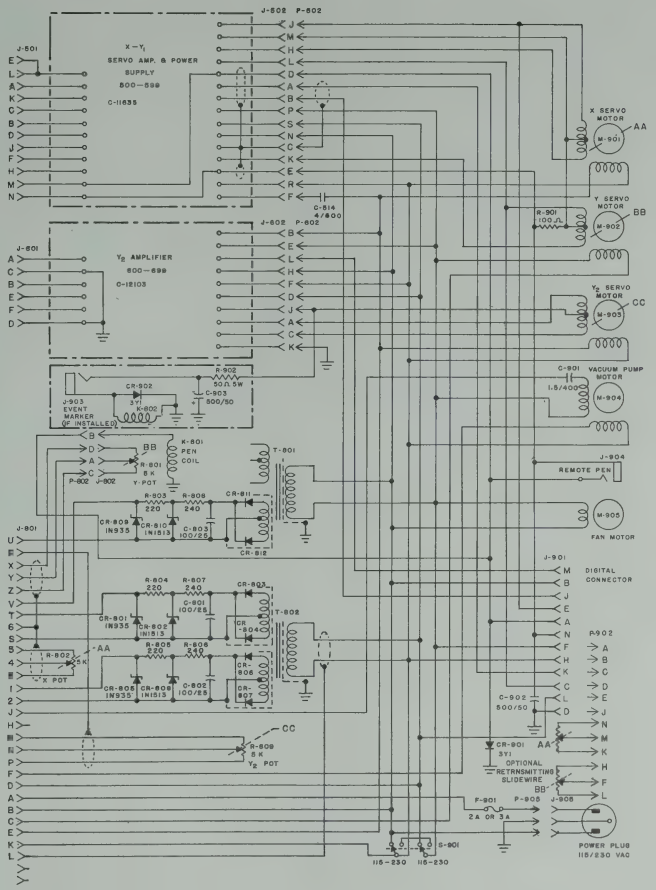


NOTES

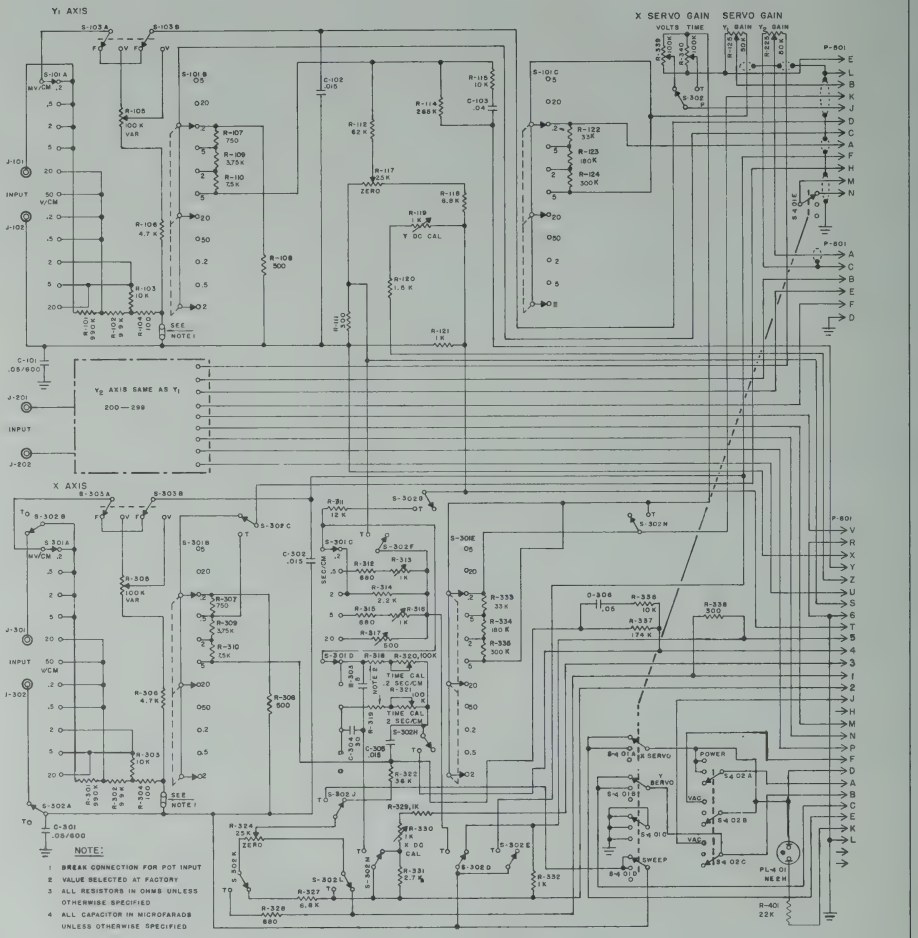
1. ALL RESISTORS ARE 1/4 W UNLESS OTHERWISE DESIGNATED.

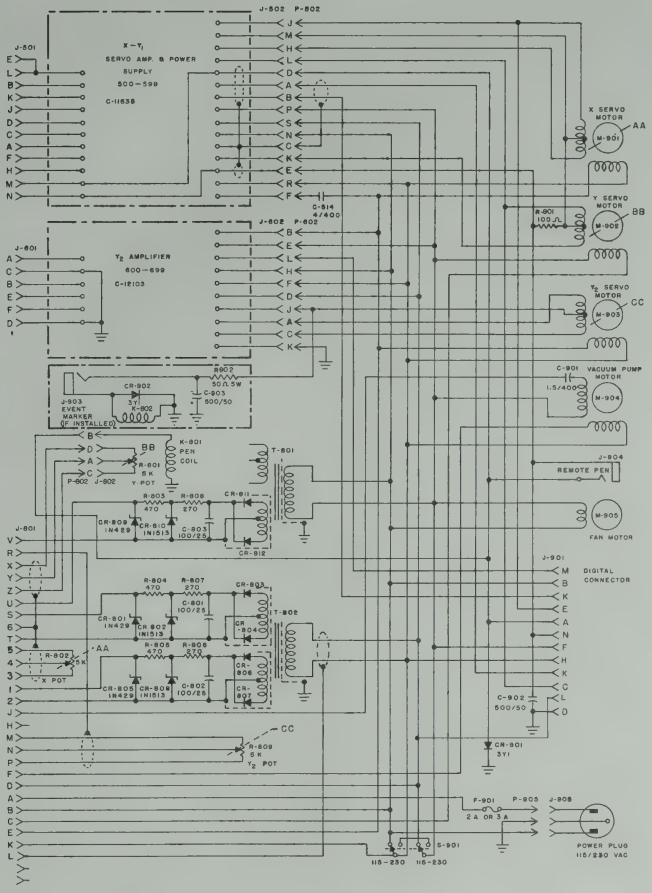
SCHEMATIC
TRANSISTOR SERVO AMPLIFIER
1 MEG OHM INPUT
MODEL 2FRA C-11635


Y1 AXIS
X SERVO GAIN
SERVO GAIN
Y1 GAIN
Y2 GAIN
VOLTS
TIME
Y2 AXIS SAME AS Y1
200—299
X AXIS
NOTE:
1 BREAK CONNECTION FOR POT INPUT
2 VALUE SELECTED AT FACTORY
3 ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
4 ALL CAPACITOR IN MICROFARADS UNLESS OTHERWISE SPECIFIED



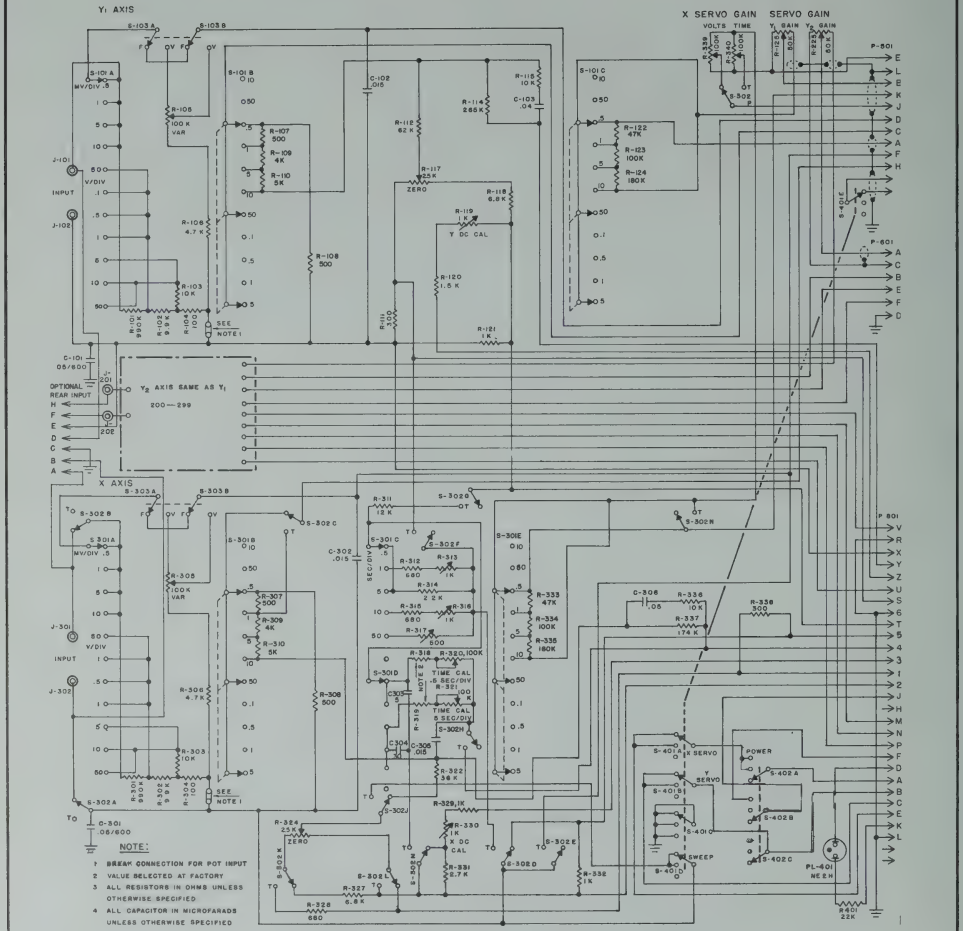
SCHEMATIC
MODEL 2FRA (WITHOUT AUTOGRIP)
D-12607

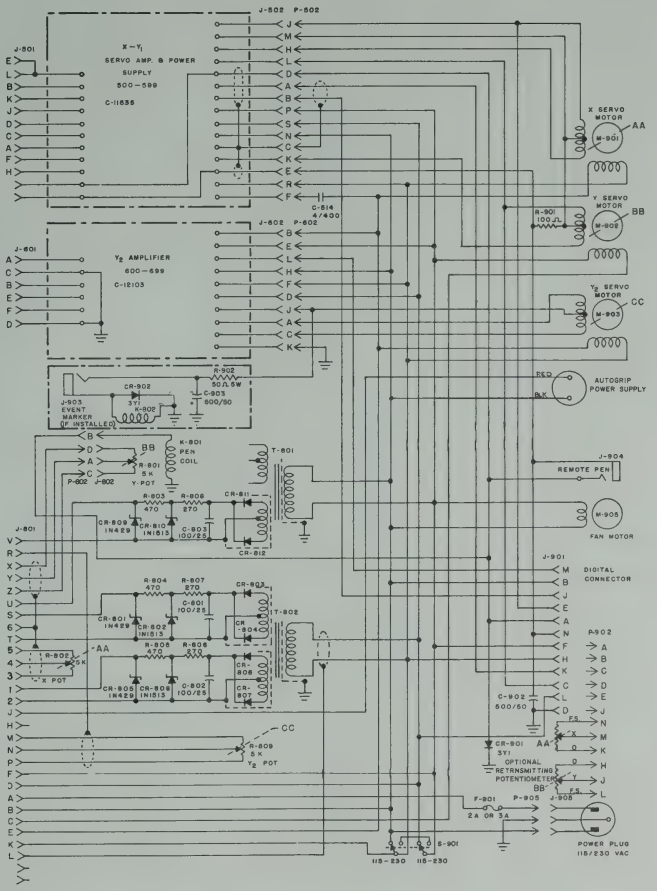

Y1 AXIS
X SERVO GAIN
SERVO GAIN
VOLTS
TIME
Y1 GAIN
Y2 GAIN
P-601
J-101
J-102
J-201
J-202
J-301
J-302
INPUT
Y2 AXIS SAME AS Y1
200—299
X AXIS
NOTE:
1 BREAK CONNECTION FOR POT INPUT
2 VALUE SELECTED AT FACTORY
3 ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
4 ALL CAPACITOR IN MICROFARADS UNLESS OTHERWISE SPECIFIED
POWER
Y SERVO
X SERVO
SWEEP
NEON



2FRAM

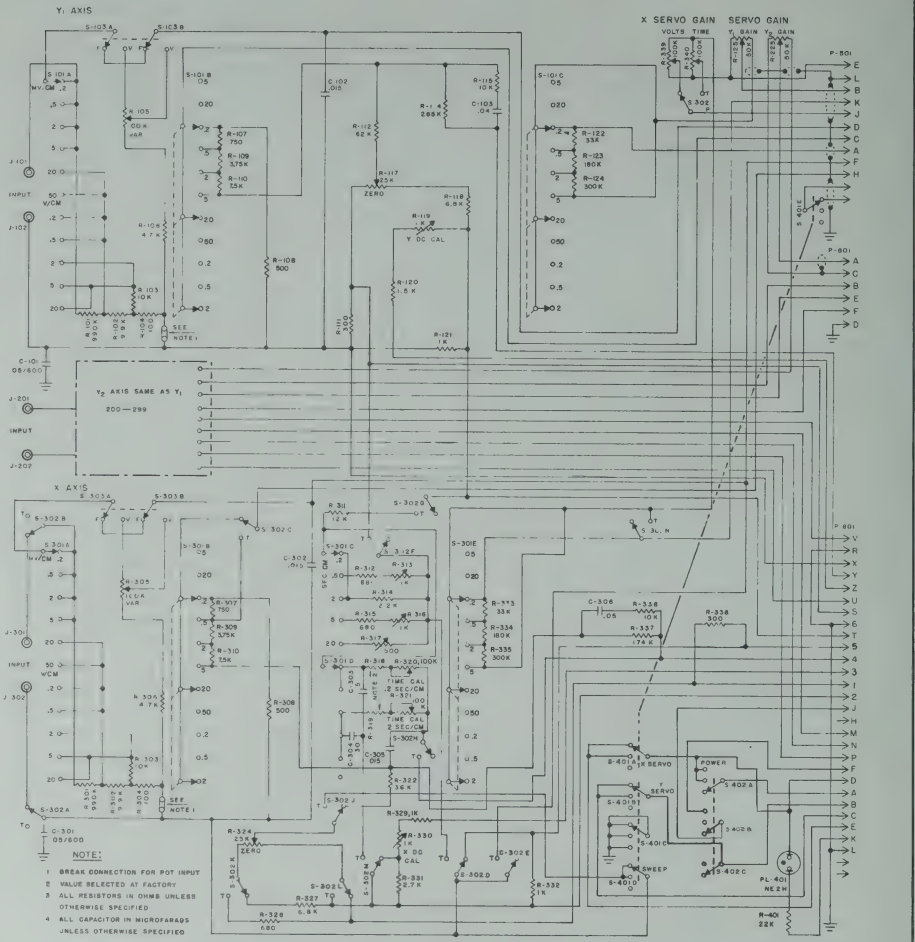
SCHEMATIC
MODEL 2FRAM (WITHOUT AUTOGRIP)
D-13520

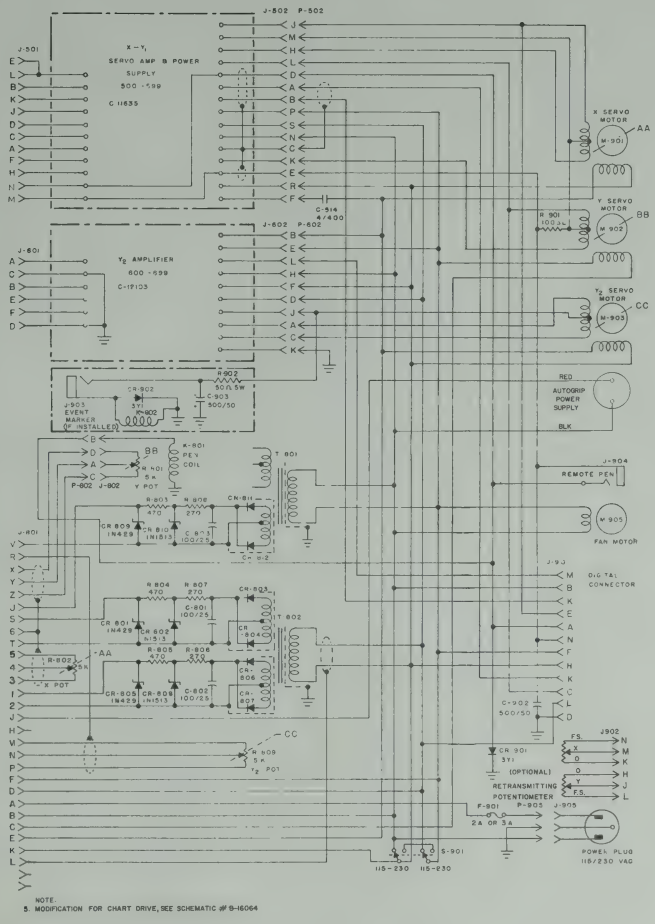

Y1 AXIS
X SERVO GAIN
SERVO GAIN
VOLTS
TIME
Y1 GAIN
Y2 GAIN
X AXIS
Y2 AXIS SAME AS Y1
OPTIONAL REAR INPUT
INPUT
SEE NOTE 1
Y DC CAL
ZERO
TIME CAL .5 SEC/DIV
TIME CAL 5 SEC/DIV
X SERVO
Y SERVO
SWEEP
POWER
NOTE:
1 BREAK CONNECTION FOR POT INPUT
2 VALUE SELECTED AT FACTORY
3 ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
4 ALL CAPACITOR IN MICROFARADS UNLESS OTHERWISE SPECIFIED



5. MODIFICATION FOR CHART DRIVE, SEE SCHEMATIC # B-15054

SCHEMATIC
ELECTROSTATIC HOLD-DOWN
MODEL 2FRA D-15034


Y1 AXIS
X SERVO GAIN
SERVO GAIN
VOLTS
TIME
Y1 GAIN
Y2 GAIN
Y2 AXIS SAME AS Y1
200 — 299
X AXIS
INPUT
SEE NOTE 1
TIME CAL
2 SEC/CM
X DC CAL
Y DC CAL
ZERO
POWER
SERVO
SWEEP
NOTE:
1 BREAK CONNECTION FOR POT INPUT
2 VALUE SELECTED AT FACTORY
3 ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
4 ALL CAPACITOR IN MICROFARADS UNLESS OTHERWISE SPECIFIED



NOTE:
5. MODIFICATION FOR CHART DRIVE, SEE SCHEMATIC # B-16064

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2FRAM (WITH AUTOGRIP)
D-16131

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PRINTED IN U.S.A.

MANUAL CHANGES

2FRA/2FRAM
TWO PEN RECORDER
Includes MODEL 2FR
Manual Printed: February 1965

Make all corrections in this manual according to errata below, then check the following table for your instrument serial prefix (3 digits) or serial number (8 digits) and make any listed change(s) in the manual.

*NEW ITEM

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES
610	I
* 619	I II

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES

ERRATA

Pen lift is designed for optimum operation with instrument in vertical position. For operation in the horizontal position, use the Model 2FA bench type unit which has optimum performance in the horizontal plane.

CHANGE I

Section VII

Change the description of the following parts under the heading "PARTS LIST CONTROL BOX AND MECHANICAL ASSEMBLY" (Do not include parts for metric models).

C-103	----------	Factory selected value	
C-203	----------	Factory selected value	
C-306	----------	Factory selected value	
CR-101	1902-0777	Diode, Zener, 5.9 to 6.3V	Transistron IN825
CR-201	1902-0777	Diode, Zener, 5.9 to 6.3V	Transistron IN825
CR-301	1902-0777	Diode, Zener, 5.9 to 6.3V	Transistron IN825
CR-801	1902-0786	Diode, Zener, 9.0V±5%	Transistron IN825
CR-802	250-0030	Diode, Zener	Sylvania #169126
CR-805	1902-0786	Diode, Zener, 9.0V±5%	Transistron IN825

Change C for 9320-1305

July 1, 1966

CR-808	250-0030	Diode, Zener	Sylvania #169126
CR-809	1902-0786	Diode, Zener, 9.0V± 5%	Transitron IN937
CR-810	250-0030	Diode, Zener	Sylvania #169126
R-112	241-0249	Resistor, Composition 180K, 1/4W, 5%	Allen Bradley
R-115	0684-8231	Resistor, Composition 82K, 1/4W, 10%	Allen Bradley
R-118	243-0327	Resistor, WW, 2K, 1%	Cinema CE542E
R-120	243-0412	Resistor, WW, 1.5K, 1%	Cinema CE542E
R-122	241-0322	Resistor, Composition 9.1K, 1/4W, 5%	Allen Bradley
R-123	241-0238	Resistor, Composition 82K, 1/4 W, 10%	Allen Bradley
R-124	241-0238	Resistor, Composition 82K, 1/4W, 10%	Allen Bradley
R-125	236-0075	Resistor, Variable, 20K	CTS UPE-70
R-126	241-0237	Resistor, Composition 20K, 1/4W, 5%	Allen Bradley
R-212	241-0249	Resistor, Composition 180K, 1/4W, 5%	Allen Bradley
R-215	0684-8231	Resistor, Composition 82K, 1/4W, 10%	Allen Bradley
R-218	243-0327	Resistor, WW, 2K, 1%	Cinema CE542E
R-220	243-0412	Resistor, WW, 1.5K, 1%	Cinema CE542E
R-222	241-0322	Resistor, Composition 9.1K, 1/4W, 10%	Allen Bradley
R-223	241-0238	Resistor, Composition 82K, 1/4W, 5%	Allen Bradley
R-226	241-0237	Resistor, Variable, 20K	CTS UPE-70

R-329	243-0458	Resistor, WW, 1.7K, 1%	Cinema CE542E
R-333	241-0322	Resistor, Composition 9.1K, 1/4W, 5%	Allen Bradley
R-334	241-0238	Resistor, Composition, 82K, 1/4W, 5%	Allen Bradley
R-335	241-0238	Resistor, Composition 82K, 1/4W, 5%	Allen Bradley
R-336	0684-4731	Resistor, Composition 47K, 1/4W, 10%	Allen Bradley
R-338	243-0427	Resistor, WW, 500 ohm, 1%	Cinema CE542
R-339	236-0075	Resistor, Variable, 20K	CTS UPE-70
R-340	236-0075	Resistor, Variable, 20K	CTS UPE-70
R-801	M-15724	Resistor, Y-axis, Rebalance 5K	Moseley
R-802	M-15207	Resistor, X-axis Rebalance 5K	Moseley
R-809	M-15206	Resistor, Yy-axis Rebalance 5K	Moseley
R-901	240-0019	Resistor, 50 ohm, 5W	Clarostat V5F

Change the description of the following parts under the heading "PARTS LIST CONTROL BOX AND MECHANICAL ASSEMBLY" (metric model only).

R-122	241-0263	Resistor, Composition 18K, 1/4W, 5%	Allen Bradley
R-123	241-0307	Resistor, Composition 9.1K, 1/4W, 5%	Allen Bradley
R-124	241-0293	Resistor, Composition 150K, 1/4W, 5%	Allen Bradley
R-222	241-0263	Resistor, Composition 18K, 1/4W, 5%	Allen Bradley
R-223	241-0307	Resistor, Composition 91K, 1/4W, 5%	Allen Bradley

R-224	241-0293	Resistor, Composition 150K, 1/4W, 5%	Allen Bradley
R-333	241-0263	Resistor, Composition 18K, 1/4W, 5%	Allen Bradley
R-334	241- 0307	Resistor, Composition 91K, 1/4W, 5%	Allen Bradley
R-335	241-0293	Resistor, Composition 150K, 1/4W, 5%	Allen Bradley

Under the heading "PARTS LIST-X AND Y, AMPLIFIERS", Change the following.

P/N M-18074
(Refer to schematic B-18066)

C-503	231-0070	Capacitor, Electrolytic 50mfd, 100V	Sprague 30D506G003BB4
C-510	234-0032	Capacitor, Metalized mylar 0.5mfd, 100V	Electron M1-504
C-520	234-0032	Capacitor, Metalized mylar 0.5mfd, 100V	Electron M1-504
R-536	240-0064	Resistor, 75ohm, 5W	Sprague 243E
R-543	241-0257	Resistor, Composition 47K, 1/4W, 10%	Allen Bradley
TR-501	256-0055	Transistor, 2N 508A	G E 30002
TR-502	256-0055	Transistor, 2N 508A	G E 30002

Add the following:

C-523	234-0035	Capacitor, 0.1mfd, 100V	C-D #WMF 1 PIE
C-524	231-0095	Capacitor, Electrolytic 50mfd, 10V	Sprague
R-544	241-0160	Resistor, Composition 15K, 1/4W, 10%	Allen Bradley
R-545	241-0160	Resistor, Composition 15K, 1/4W, 10%	Allen Bradley

R-546	241-0146	Resistor, Composition 10K, 1/4W, 10%	Allen Bradley
R-547	241-0146	Resistor, Composition 10K, 1/4W, 10%	Allen Bradley

Under the heading "PARTS LIST - Y[illegible] AMPLIFIER", Change the following:

P/N M-18074
(Refer to schematic B-18067)

C-506	231-0070	Capacitor, Electrolytic 50mfd, 3V	Sprague TE 1050
C-518	234-0032	Capacitor, Metalized 0.5mfd, 100V	Electron M1-504
C-519	234-0032	Capacitor, Metalized 0.5mfd, 100V	Electron M1-504
C-521	231-0087	Capacitor, Electrolytic 50mfd, 50V	Sprague TE 1307
R-532	241-0180	Resistor, Composition 3.9K, 1/4W, 10%	Allen Bradley
TR-501	256-0055	Transistor, 2N508A	G E 30002
TR-502	256-0055	Transistor, 2N508A	G E 30002

Add the following:

C-526	231-0087	Capacitor, Electrolytic 50mfd, 50V	Sprague 30D506G0500H4
R-542	241-0146	Resistor, Composition 10K, 1/4W, 10%	Allen Bradley
R-541	241-0146	Resistor, Composition 10K, 1/4W, 10%	Allen Bradley

Pages 7-18, 7-21- and 7-26 through 7-29, Replace schematics:

Was	Replaced by
C-12103	C-18067-B
C-11635	C-18066-B
D-15034	D-16686-F
D-16131	D-18164-E

CHANGE II

Page 7-4, Change R-902 to read as follows:

R-902	240-0050	Resistor, Power, 150 ohm, 5w	Sprague	243E

Page 7-3, Change R-320 and R-321 to read as follows:

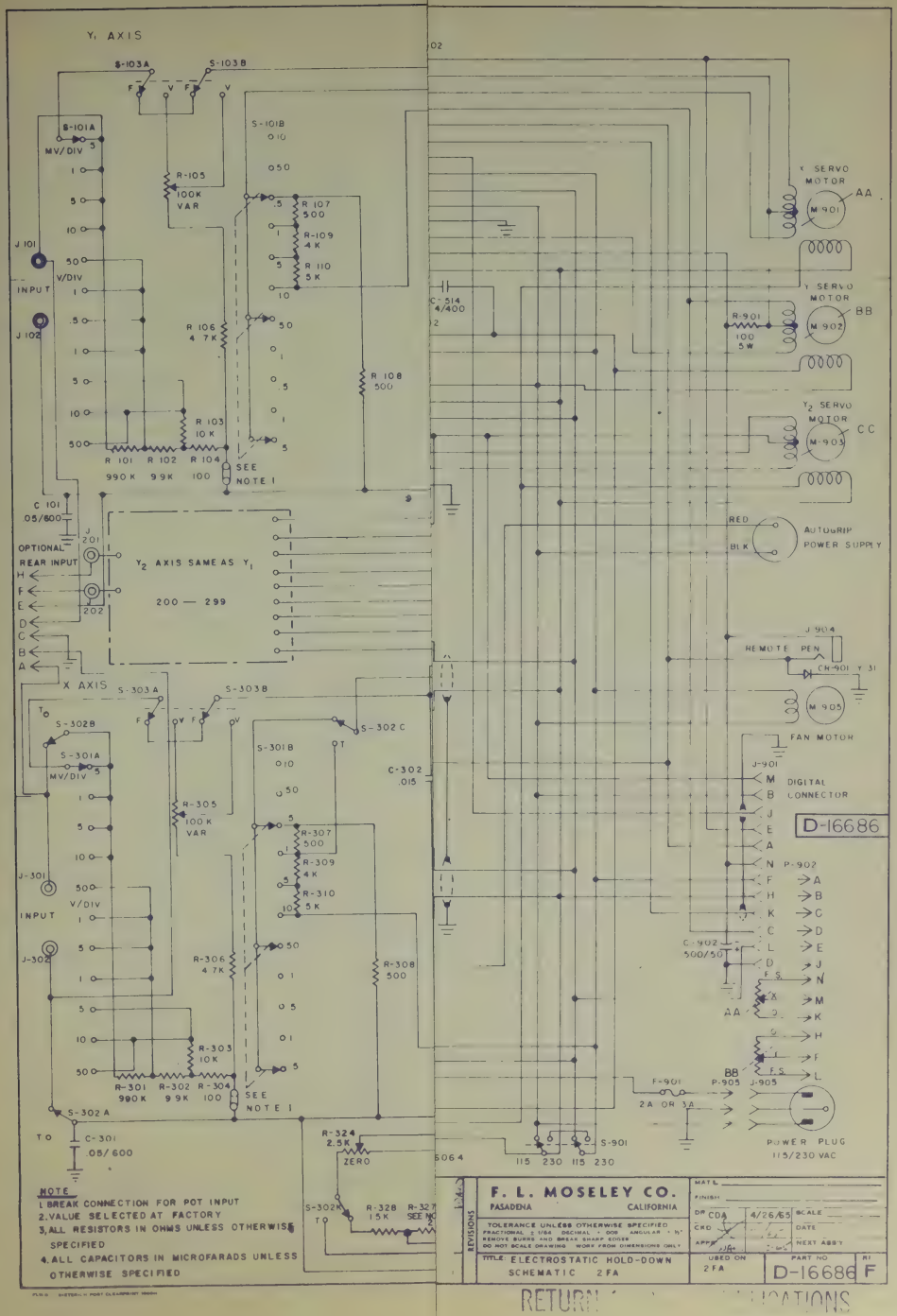
R-320	2100-0144	Resistor, Variable, 250K	CTS	UPM7ORE
R-321	2100-0144	Resistor, Variable, 250K	CTS	UPM7ORE

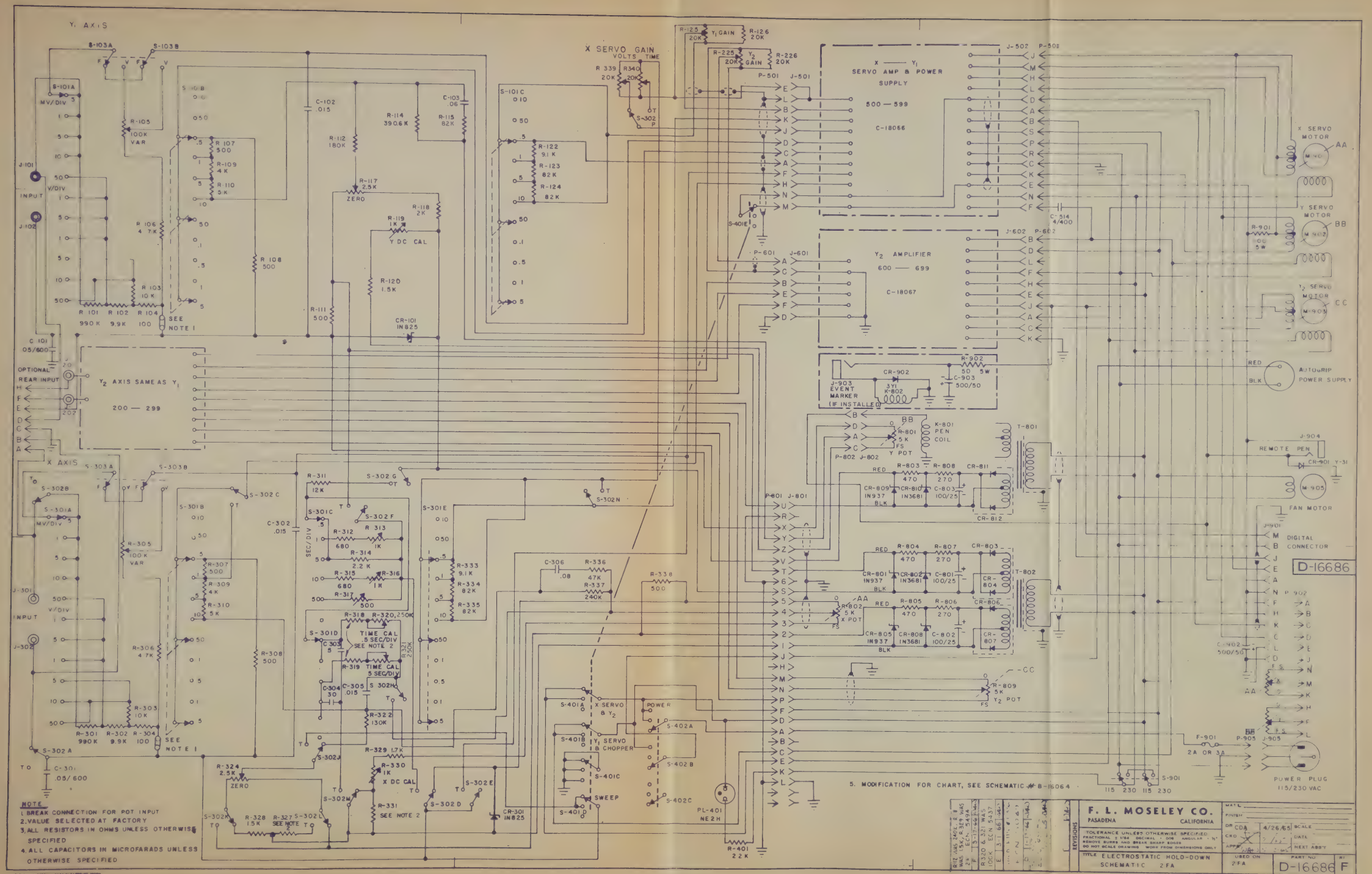
Page 7-15, Change B/N 55 to read as follows:

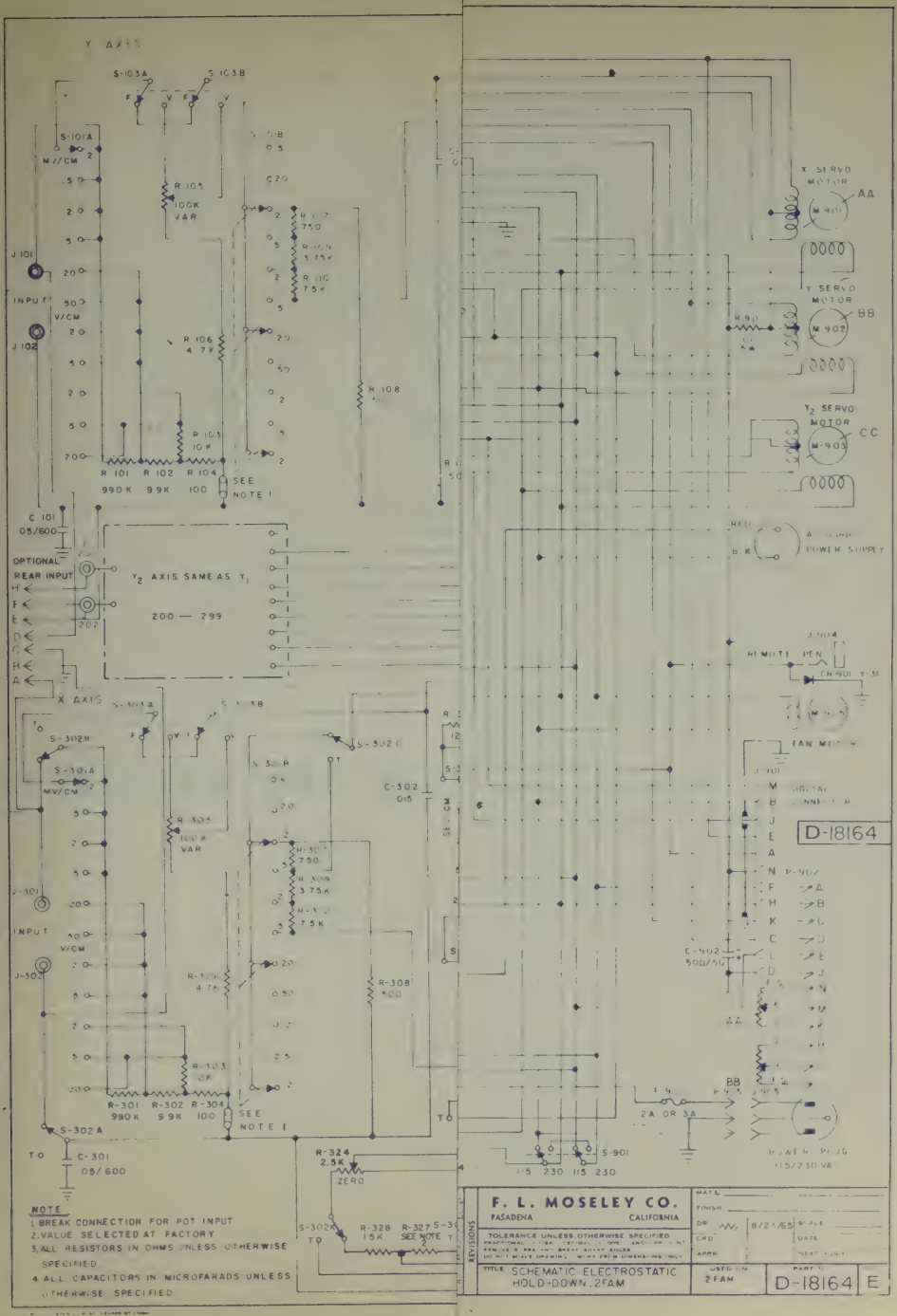
B/N	P/N	Description	Mfr. Designation
55	1410-0296	Bushing	Oilite

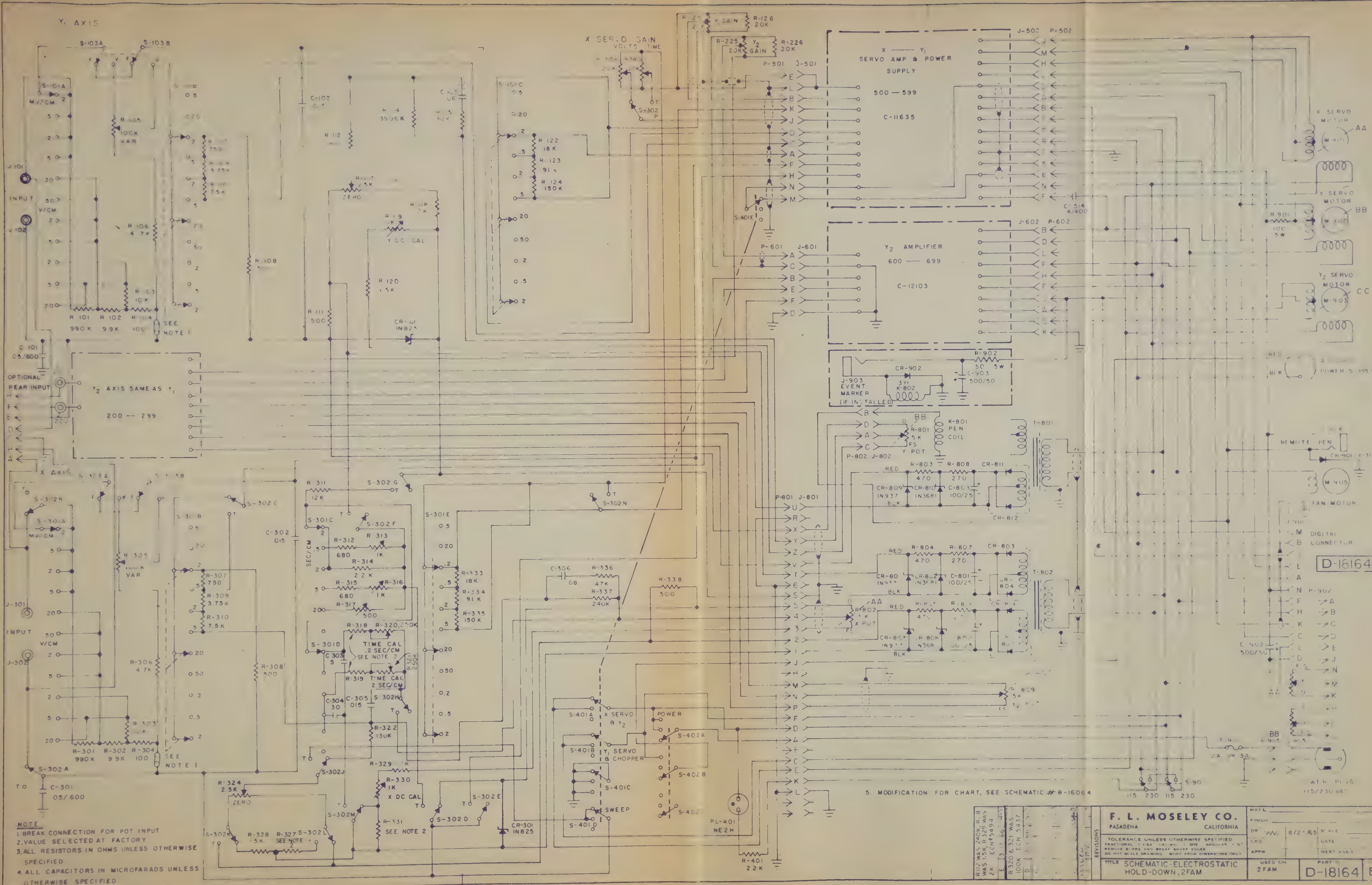
SCHEMATICS (attached D-16686 and D-18164)

Change R-901 to 50 ohm. Was 100 ohm
Change R-902 to 150 ohm. Was 50 ohm.
Change R-320 to 250K ohm. Was 100K ohm.
Change R-321 to 250K ohm. Was 100K ohm.


Y1 AXIS
S-103A
S-103B
S-101A
MV/DIV
S-101B
R-105
100K VAR
R 107 500
R-109 4K
R 110 5K
J 101
J 102
INPUT
V/DIV
R 106 4.7K
R 108 500
R 103 10K
R 101 990K
R 102 9.9K
R 104 100
SEE NOTE 1
C 101 .05/600
OPTIONAL REAR INPUT
J 201
J 202
Y2 AXIS SAME AS Y1
200 — 299
X AXIS
S-303A
S-303B
S-302B
S-301A
S-301B
S-302C
R-305 100K VAR
R-307 500
R-309 4K
R-310 5K
C-302 .015
J-301
J-302
R-306 4.7K
R-308 500
R-303 10K
R-301 990K
R-302 9.9K
R-304 100
S-302A
TO C-301 .05/600
R-324 2.5K ZERO
S-302K TO
R-328 1.5K
R-327 SEE NO
NOTE
1. BREAK CONNECTION FOR POT INPUT
2. VALUE SELECTED AT FACTORY
3. ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
4. ALL CAPACITORS IN MICROFARADS UNLESS OTHERWISE SPECIFIED
X SERVO MOTOR
M 901
AA
Y SERVO MOTOR
M 902
BB
R-901 100 5W
Y2 SERVO MOTOR
M 903
CC
RED
BLK
AUTOGRIP POWER SUPPLY
J 904
REMOTE PEN
CR-901
M 905
FAN MOTOR
J-901
DIGITAL CONNECTOR
D-16686
P-902
C-902 500/50
F-901 2A OR 3A
P-905
J-905
S-901
115 230 115 230
POWER PLUG 115/230 VAC
F. L. MOSELEY CO.
PASADENA CALIFORNIA
TOLERANCE UNLESS OTHERWISE SPECIFIED
FRACTIONAL ± 1/64 DECIMAL ± .005 ANGULAR ± ½°
REMOVE BURRS AND BREAK SHARP EDGES
DO NOT SCALE DRAWING WORK FROM DIMENSIONS ONLY
MAT'L
FINISH
DR CDA 4/26/65
CKD
APP'D
SCALE
DATE
NEXT ASSY
TITLE ELECTROSTATIC HOLD-DOWN SCHEMATIC 2FA
USED ON 2FA
PART NO D-16686
REVISIONS
RETURN




Y AXIS
S-103A
S-103B
S-101A
MV/CM
J 101
INPUT
J 102
R 105
100K
VAR
R 106
4.7K
R 108
R 101
990K
R 102
9.9K
R 104
100
SEE
NOTE 1
C 101
05/600
OPTIONAL
REAR INPUT
Y2 AXIS SAME AS Y1
200 — 299
X AXIS
S-302H
S-301A
J-301
J-302
R-305
R-306
R-307
750
R-309
3.75K
R-310
7.5K
R-308
R-303
R-301
990K
R-302
9.9K
R-304
100
S-302A
C-301
05/600
C-302
015
R-324
2.5K
ZERO
R-328
15K
R-327
S-302A
TO
X SERVO MOTOR
M-901
AA
Y SERVO MOTOR
M-902
BB
Y2 SERVO MOTOR
M-903
CC
POWER SUPPLY
J-904
REMOTE PEN
CR-901
FAN MOTOR
J-901
D-18164
P-902
C-902
500/50
2A OR 3A
S-901
115 230 115 230
POWER PLUG
115/230 VA
NOTE
1. BREAK CONNECTION FOR POT INPUT
2. VALUE SELECTED AT FACTORY
3. ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
4. ALL CAPACITORS IN MICROFARADS UNLESS OTHERWISE SPECIFIED
REVISIONS
F. L. MOSELEY CO.
PASADENA CALIFORNIA
TOLERANCE UNLESS OTHERWISE SPECIFIED
MATL
FINISH
DR
8/21/65
CKD
APPR
SCALE
DATE
NEXT ASSY
USED ON
2 FAM
TITLE SCHEMATIC ELECTROSTATIC HOLD-DOWN, 2FAM
PART NO.
D-18164
E


Y1 AXIS
X SERVO GAIN
Y1 GAIN
R-126 20K
R-225
Y2 GAIN
R-226 20K
X — Y1 SERVO AMP & POWER SUPPLY
500 — 599
C-11635
J-502 P-502
J-602 P-602
Y2 AMPLIFIER
600 — 699
C-12103
P-501 J-501
P-601 J-601
X SERVO MOTOR
AA
Y SERVO MOTOR
BB
Y2 SERVO MOTOR
CC
R-901
C-514 4/400
R-902 50 5W
CR-902
C-903 500/50
J-903 EVENT MARKER (IF INSTALLED)
K-802
K-801 PEN COIL
R-801 5K Y POT
P-802 J-802
T-801
T-802
REMOTE PEN
FAN MOTOR
DIGITAL CONNECTOR
D-18164
P-801 J-801
R-803 470
R-808 270
CR-811
CR-809 IN937
CR-810 IN3681
C-801 100/25
R-804 470
R-807 270
CR-803
R-802 X POT
R-809
C-902 500/50
A.C. PLUG 115/230 VAC
S-90
115 230 115 230
2A OR 3A
Y2 AXIS SAME AS Y1
200 — 299
OPTIONAL REAR INPUT
INPUT V/CM
J-101
J-102
J-301
J-302
X AXIS
S-101A
S-103A
S-103B
S-302A
R-101 990K
R-102 9.9K
R-104 100
R-105 100K VAR
R-106 4.7K
R-108
R-111 500
R-112
R-120 1.5K
R-122 18K
R-123 91K
R-124 150K
CR-101 IN825
C-101 .05/600
C-102
Y DC CAL
ZERO
SEE NOTE 1
R-301 990K
R-302 9.9K
R-304 100
R-305 100K VAR
R-306 4.7K
R-307 750
R-309 3.75K
R-310 7.5K
R-308 500
R-311 12K
R-312 680
R-313 1K
R-314 2.2K
R-315 680
R-316 1K
R-317 500
R-318
R-319 TIME CAL 2 SEC/CM
R-320, 250K
TIME CAL .2 SEC/CM SEE NOTE 2
R-322 130K
R-324 2.5K ZERO
R-328 1.5K
R-327 SEE NOTE
R-329 1K
R-330 1K X DC CAL
R-331 SEE NOTE 2
R-333 18K
R-334 91K
R-335 150K
R-336 47K
R-337 240K
R-338 500
C-301 .05/600
C-302 .015
C-303 5
C-304 30
C-305 .015
C-306 .08
CR-301 IN825
S-302 G
S-302 F
S-302 N
S-302 H
S-302 J
S-302 M
S-302 D
S-302 E
S-302 K
S-302 L
S-301 C
S-301 D
S-301 E
SEC/CM
S-401A X SERVO & Y2
S-401B Y1 SERVO & CHOPPER
S-401C
S-401D SWEEP
POWER
S-402A
S-402B
PL-401 NE2H
R-401 22K
5. MODIFICATION FOR CHART, SEE SCHEMATIC # 8-16064
NOTE
1. BREAK CONNECTION FOR POT INPUT
2. VALUE SELECTED AT FACTORY
3. ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
4. ALL CAPACITORS IN MICROFARADS UNLESS OTHERWISE SPECIFIED
R112 WAS 240K, R, 8 WAS 1.5K, R 329 WAS 2K ECN#5494
R 320 & 321 WAS 100K ECN 5437
REVISIONS
F. L. MOSELEY CO.
PASADENA CALIFORNIA
TOLERANCE UNLESS OTHERWISE SPECIFIED
REMOVE BURRS AND BREAK SHARP EDGES
DO NOT SCALE DRAWING WORK FROM DIMENSIONS ONLY
MAT'L
FINISH
DR
CKD
APPR
SCALE
DATE
NEXT ASSY
TITLE SCHEMATIC-ELECTROSTATIC HOLD-DOWN, 2FAM
USED ON 2FAM
PART
D-18164 E

9320-1305

2FRA / 2FRAM TWO PEN RECORDER

includes MODEL 2FR

OPERATING AND SERVICE MANUAL

HEWLETT PACKARD hp MOSELEY DIVISION

WARRANTY

All our Instruments are warranted to be free from defects in material and workmanship for a period of one year after delivery to the original purchaser. Liability under this warranty is limited to servicing, adjusting, or the replacement of the defective parts (other tubes, fuses, or batteries) on any instrument returned for this purpose, transportation charges prepaid.

For assistance of any kind, including help with instruments under warranty, contact your nearest Hewlett-Packard field office for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, except transportation charges. Estimates of charges on non-warranty or other service work will always be supplied, if required, before work begins.

OPERATING AND SERVICE MANUAL

for

MODEL 2FRA & 2FRAM
TWO PEN RECORDER
(including MODEL 2FR)

by

HEWLETT PACKARD hp MOSELEY DIVISION

433 N. Fair Oaks Avenue
Pasadena, California

Printed February 1965

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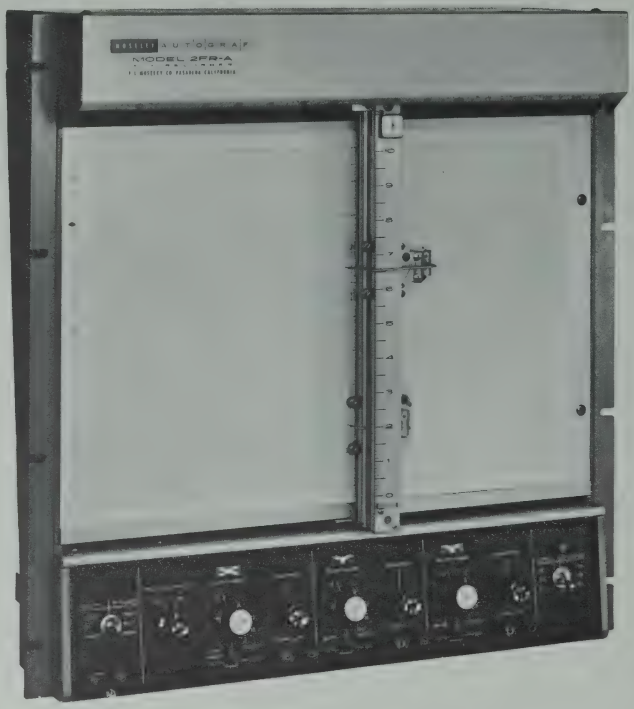


FIGURE 1-1. MODEL 2FRA TWO-PEN RECORDER

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION

1-2. PURPOSE AND CAPABILITY. The Moseley Models 2FRA and 2FRAM are two-pen, three axis graphic recorders designed to plot two cartesian coordinate curves simultaneously from DC signals representing a single independent variable and two dependent variables. The two pens move vertically on a single carriage which travels horizontally. Each pen has full scale plotting range in both X and Y directions with less than 0.1 inch horizontal separation. The AUTOGRIP electric platen accepts standard graph paper with 10" x 15" (25 cm x 38 cm) recording area or smaller. A built-in sweep generator provides a time base on the horizontal axis for plotting two dependent variables against time. Each axis is controlled by an electrically independent servo mechanism with one megohm input resistance on eleven fixed ranges. Variable range control is provided to accommodate arbitrary voltage situations.

1-3. MANUAL COVERAGE. This manual applies to Models 2FRA and 2FRAM beginning with Serial No. 79, and Model 2FR, Serial No. 1 through 78. Models 2FR and 2FRA are scaled and calibrated in inches; Model 2FRAM is scaled and calibrated in centimeters. Section VI covers differences in specifications, operation and maintenance of early production Model 2FR.

1-4. SPECIFICATIONS

RECORDING MECHANISM: Three independent servo-actuated drives, one for each axis, X, Y, and Y_2. All three systems are isolated and free of ground.

RECORDING PLATEN: AUTOGRIP electric paper holddown grips any dimension paper up to 11" x 17" (28 x 43 cm).

DC INPUT RANGES: Standard Unit: Eleven calibrated ranges for each axis: 0.5, 1.0, 5, 10, 50 millivolts/division (inch) and 0.1, 0.5, 1, 5, 10, 50 volts/division (inch).

Metric Unit: Eleven calibrated ranges for each axis: 0.2, 0.5, 2, 5, 20, 50 millivolts/centimeter and 0.2, 0.5, 2, 5, 20 volts/centimeter.

Both models have potentiometric input available on each axis for operation with essentially zero current drain on the four lowest ranges. A stepless range control feature permits arbitrary full scale voltage settings on any range up to the maximum limits of the instrument (500 volts on Y_1, Y_2 axes; 750 volts on X axis).

TIME BASE INTERVALS: Standard Unit: Five calibrated sweeps of 0.5, 1, 5, 10, and 50 seconds/division (inch) on X axis only.

Metric Unit: Five calibrated sweeps of 0.2, 0.5, 2, 5, and 20 seconds/centimeter.

Basic sweep ranges provide 7.5, 15, 75, 150 and 750 seconds for full scale traversal.

INPUT RESISTANCE: One megohm at null on all fixed ranges. In variable range mode, 100,000 ohms on four most sensitive steps and one megohm on remaining steps.

RECORDING SPEED: Maximum speed on both Y axes is 20 inches/second (50 cm/sec): on X axis, 10 inches/second (25 cm/sec).

STANDARDIZATION: Continuous electronic reference, zener diode controlled.

ACCURACY: Better than 0.2% of full scale with resettability better than 0.1% of full scale. Time base accuracy better than 5% of full scale, adjustable to 1%.

POWER REQUIREMENTS: 115/230 volts, 50/60 cps, approximately 200 volt/amperes. Slide switch determines voltage acceptance.

PHYSICAL DIMENSIONS: Overall: 19-7/32" high, 19" wide, 8" deep. Inside rack clearance; 17-3/4" wide, 5-5/8" maximum depth. (See Figure 1-2.)

1-5. ACCESSORY EQUIPMENT

1-6. While the Model 2FRA two-pen X-Y recorder has many direct uses, its utilization may be increased by the addition of accessory equipment available for specialized applications. Because of the rack mounting design, this model will not accept roll chart accessories. Curve followers, line followers, and character printers also are not available for use with these instruments due to the dual pen carriage beam.

1-7. LOGARITHMIC CONVERTER. Moseley Model 60D Logarithmic Converter accepts either AC or DC input voltages and delivers an output DC voltage proportional to the logarithm of the positive peak amplitude of the input voltage. This converts the recorder input on one axis from linear to logarithmic (db) scale, permitting direct plotting on semi-log paper. Log-log plotting may be accomplished using a converter in each axis. Since the logarithmic scale compresses the higher amplitudes and expands the lower ones, wide ranges in level with maximum accuracy at low amplitudes may be obtained. The Model 60DM converter is available for use with the metrically scaled Model 2FRAM.

1-8. TYPE 101 WAVEFORM TRANSLATOR. This unique instrument converts high speed repetitive waveforms displayed on an oscilloscope to signals which, when applied to an X-Y recorder, reproduce the waveform as a permanent, inked record.

1-9. EVENT MARKER. A third pen, when ordered as an optional feature, is mounted in a fixed position near the bottom of the pen carriage. The purpose of this pen is to insert identifying marks on the lower margin of the chart. It may be actuated by a remote contact closure in the operation system circuitry to designate significant "events" during the test procedure.

1-10. TYPE A-1 AC-DC CONVERTER. Any two axes of the recorder may be used for plotting AC signals by using this two-channel device which supplies a DC voltage proportional to the positive peak amplitude of the AC input signal. Frequency response of the converter is 20 cps to 100 KC. A Type A-1R is available for rack mounting.

WARNING: When accessory equipment designed for a 20,000 ohm load is used, care must be exercised to provide correct recorder input loading. A 20,408 ohm, 0.1%, resistor connected across the recorder input terminals provides the necessary load. Some accessories require different loading. Refer to the accessory operating manual for this information. Moseley Model 17003A provides the necessary shunt and conveniently plugs into the input receptacles. It is also equipped with GR input receptacles.

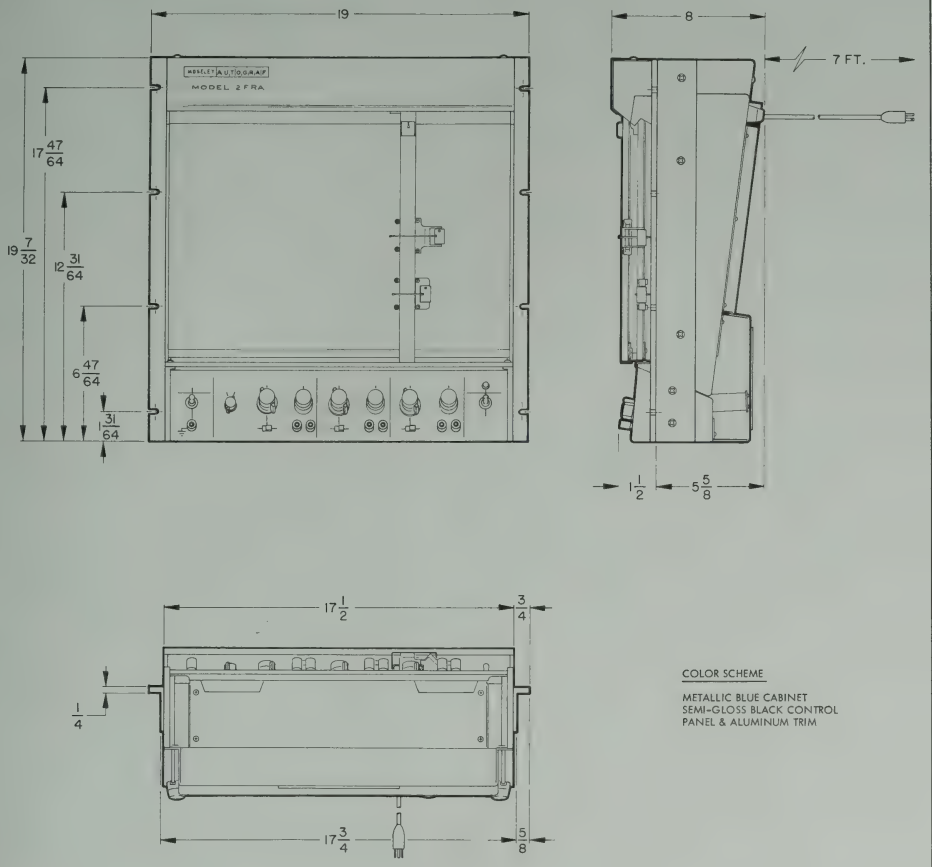


FIGURE 1-2. PHYSICAL DIMENSIONS

SECTION II
INSTALLATION AND INSPECTION

2-1. INTRODUCTION

2-2. This section supplies information for incoming inspection, installation of recorders and recorder options, storage, and shipping.

2-3. INCOMING INSPECTION

2-4. MECHANICAL CHECK. If there is evidence of damage to the shipping carton, ask that an agent of the carrier be present when the instrument is unpacked. Inspect for mechanical damage, scratches, dents, broken knobs, etc. Also check the cushioning material for signs of severe stress.

2-5. PERFORMANCE INSPECTION. The electrical performance should be verified as soon as possible after receipt. A performance inspection chart, figure 2-2, outlines suitable procedure.

2-6. CLAIM FOR DAMAGE. If there is evidence of mechanical damage or failure to meet specifications on receipt, notify the carrier and nearest Hewlett-Packard field office immediately. (A list of field offices is in the back of this manual.) Retain shipping carton and padding material for inspection by the carrier. The field office will arrange for the repair or replacement of your instrument without waiting for settlement of a claim against the carrier.

2-7. STORAGE

2-8. If the instrument is to be stored for an extended period of time both pens should be removed and the carriage arm and pen carriages secured to one side to prevent damage during handling. Seal the instrument in a moisture proof covering and repackage in a container similar to the original factory carton.

2-9. SHIPPING

2-10. Before returning the instrument for any reason, notify the local field sales offices of the difficulty encountered, the model and serial number of the instrument, and request shipping instructions. The following precautions should be taken when repackaging for shipment.

1. Remove both pens.

2. Secure the carriage arm and both pen carriages to one side of the recorder to prevent movement while in transit.

3. If being returned for repair, do not send power cord or accessory kit.

4. Wrap the instrument in heavy paper or plastic and surround with three to four inches of shock-absorbing material to cushion and prevent movement inside the shipping container. The container should be sufficiently durable to prevent damage during handling.

2-11. INSTALLATION OF RECORDER

2-12. The Models 2FRA and 2FRAM are designed for rack mounting in standard 19" rack consoles. Dimensions and clearances are provided in figure 1-2 of section I.

2-13. Cooling is provided by an exhaust fan. The location or mounting of the instrument must insure adequate air circulation.

2-14. INPUT CONNECTIONS. Front input connectors are provided for all three axes on standard instruments. On option initiated with order, rear input terminals may be provided.

2-15. INSTALLATION OF OPTIONS. All recorders in the series may be equipped with optional accessories which increase versatility and use under special operating requirements. Various options are described in paragraph 1-5. They may require factory installation or be furnished in kits for customer installation.

2-16. REAR INPUT TERMINALS. Rear mounted connectors wired in parallel with the regular front terminals are usually factory installed as an ordered option. When omitted initially, a kit may be obtained for installation by the user. Simple instructions are included with the kit.

2-17. EVENT MARKER (LOWER AXIS). This is preferably a customer ordered factory installed option. Customer installation is slightly more complicated but can be accomplished with the instructions furnished.

REQUIRED INSTRUMENTS

a. DC Standard 1 volt - 50 MV-50 Volts.

b. Ohmmeter - 0 - 2 megohm range.

c. Functional step generator.

INSPECTION (Refer to section I for specifications.)

See section III for complete operating procedures.

1. Set the 115/230 selector switch at 115 volts. If 230 volts is the only available power source, set the selector at 230. Before applying power, check the fuse for proper value. A 2 ampere fuse is required for 115 volt operation and a 1 ampere fuse for the 230 volts.

2. To apply power to the recorder, place power switch in ON-ON position.

3. Check for proper operation of the remote pen lift. With the PEN-TIME switch in STANDBY, place the furnished plug in the REMOTE PEN jack on the rear of the instrument and short circuit the plug contacts. Pen should drop into writing position.

4. CALIBRATION AND ALIGNMENT CHECKS. Set both Y-axis range selectors to 0.1 volts/in and position the pen by use of the zero controls to "0" on each Y-axis and seven and one-half inches on the X-axis (mid scale). Apply a one volt DC signal to both Y-axis input terminals. The pens should be driven to 10 on the Y-axis and should not vary from the seven and one-half inch grid line. (Vertical alignment check.) A similar test is made on the X-axis with a one and one-half volt signal to drive the pen 15 inches. Set the X-axis range selector to 0.1 V/in and position the pen by use of the zero controls at "0" on the X-axis and five inches (mid scale) on the Y-axis. Apply a one and one-half volt DC signal to the X-axis input terminals. The pen should be driven to "15" on the X-axis and should not vary from the five inch grid line. (Horizontal alignment check.)

5. LINEARITY AND RESETTABILITY. Using the zero control, set the pen at the 10 inch mark on the Y-axis at approximately half scale. Set the range selector to 0.1 V/inch. Using a step attenuator, start with 0.1 volt and increase in steps of 0.1 volt until full scale is reached. Each step should line up with the major vertical grid divisions. At each step rotate the X-axis zero control to draw a reference line. This provides a linearity check. At the "0" mark on the Y-axis move the pen one division (0.1 inch) to either side. Remove the full scale voltage in steps of 0.1 volts. Each step should line up with the marks made during the linearity check. This demonstrates linearity and resettability. Repeat the procedure using 15 steps of 0.1 volts each in the X axis to determine linearity and resettability of that axis.

6. VARIABLE RANGE. Set the FIX-VAR switch to VAR and the RANGE selector at .1 V/inch; apply a 1 volt signal. Rotation of the VAR control should move the pen along the axis being checked. The variable control is operating properly if any deflection is observed. Usually movement is about 1/5 full scale.

7. TIME SWEEP CHECK. A preliminary check on the X-axis time sweep operation may be obtained using a stop watch as follows:

a. Set the FUNCTION switch to TIME.

b. Set the PEN-TIME switch to UP-RESET.

c. Set the X-axis RANGE switch to 50 secs/div. (or 20 secs/cm).

d. Move the PEN-TIME switch to SWEEP, at the same time starting stop watch.

e. Sweep error should not be greater than ±2.5 seconds per division (1 sec/cm). If sweep operates, although error is high, recalibration may be required. (See section V.)

8. INPUT RESISTANCE CHECKS. Input resistance measurement should not be attempted by using an ohmmeter, a special test procedure and circuit is required. Simply measuring input resistance with an ohmmeter will give erroneous indication.

a. Construct a test circuit as illustrated in figure 2-2.

b. Set the record attenuator control in the axis to be measured to the 0.5 millivolt/division range and adjust recorder zero control to position the pen at zero.

FIGURE 2-1. INCOMING CHECK CHART (Sheet 1 of 2)

c. Connect the low impedance, low voltage source to the input terminals as shown. (Observe polarity.)

d. With the adjustable two megohm potentiometer at zero resistance, adjust the 1K potentiometer for 10 inches pen deflection.

e. Increase the resistance of the two megohm potentiometer until the pen returns to the 5 inch scale position. At this point, the portion of the two megohm pot remaining in the circuit should measure one megohm, matching the input resistance of the recorder.

f. Higher ranges may be checked in a similar manner, using a higher voltage source.

9. ZERO OFFSET CHECK. The 2FRA is provided with one full scale of zero suppression in all axes. Set zero on the X-axis at the "0" mark (left hand margin). Apply a voltage which will drive the pen to the full scale mark (15" or 38 cm). Only sufficient voltage to drive the pen full scale should be applied. Turn the zero control fully CCW. This will reset zero, with the input voltage still applied, to approximately "0." A similar check may be performed on Y_1 and Y_2. If the exact DC voltage required for full scale deflection is not available, the variable range control should be utilized to produce full scale deflection.

FIGURE 2-1. INCOMING CHECK CHART (Sheet 2 of 2)

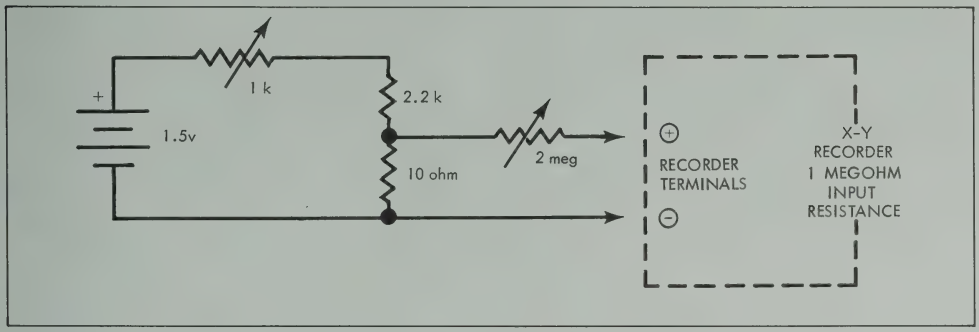


FIGURE 2-2. TEST CIRCUIT

SECTION III
OPERATION

3-1. INTRODUCTION

The basic function of the Model 2FRA and 2FRAM is to produce graphic tracings showing the relationship between two dependent variable functions and a third independent variable. Electrical signals representing these functions are applied to the input terminals of the respective axes of the instrument and the controls adjusted so that the resulting graphs will cover the desired scope of operation. Before operating, the user should become familiar with the input requirements and various control functions as outlined in the following paragraphs.

3-2. ELECTRICAL REQUIREMENTS

3-3. OPERATING POWER. Line power source may be either 115/230 volts, 50/60 cps, and single phase. A voltage conversion switch is located on the rear of the instrument. This switch must be set to either 115 or 230 as determined by the available power source. For optimum performance it is essential that the third prong of the AC power plug be grounded.

3-4. INPUT DATA SIGNALS. Input terminals must be supplied with DC signals which are linear functions of the original information. These signals must vary at a rate within the response capabilities of the instrument (10 inches/sec in the X-axis; 20 inches/sec in both Y-axes) and have amplitudes within its scale ranges, (0 to 50 volts/div (inch)). In the metric model these limits are 25 cm/sec in the X-axis; 50 cm/sec in both Y-axes; 0-20 volts/cm maximum amplitude.

3-5. INPUT CONNECTIONS. The input terminals for all three axes are located on the front panel. Rear input terminals are offered as an optional feature.

3-6. POTENTIOMETRIC INPUT. For maximum sensitivity with minimum current drain from the signal source, the recorder may be converted for potentiometric input on the four most sensitive ranges. Full scale deflection is then obtained with 7.5 millivolts on the X-axis and 5.0 millivolts on each Y-axis. To accomplish this conversion, busses must be removed from the input printed circuit board in the axis or axes desired. The busses are identified in figure 3-3. When the recorder is used in this manner the range switch must select one of the four most sensitive settings. This essentially provides four ranges of potentiometric operation. In this mode, the source impedance of the signal should be 50,000 ohms, or less.

MODEL 2FRA			
Switch Range	Full Scale Input Resistance (ohms/volt)	Full Scale (10") Current Drain (micro-amperes)	Full Scale (10") Input Resistance (ohms)
0.5 mv/div (inch)	200,000,000	0.005	1,000,000
1	100,000,000	0.01	1,000,000
5	20,000,000	0.05	1,000,000
10	10,000,000	0.1	1,000,000
50	2,000,000	0.5	1,000,000
0.1 v/div (inch)	1,000,000	1	1,000,000
0.5	200,000	5	1,000,000
1	100,000	10	1,000,000
5	20,000	50	1,000,000
10	10,000	100	1,000,000
50	2,000	500	1,000,000

FIGURE 3-1. INPUT CHART

MODEL 2FRAM			
Switch Range	Full Scale Input Resistance (ohms/volt)	Full Scale (25 cm) Current Drain (micro-amperes)	Full Scale (25 cm) Input Resistance (ohms)
0.2 mv	200,000,000	0.005	1,000,000
0.5	80,000,000	0.0125	1,000,000
2	20,000,000	0.050	1,000,000
5	8,000,000	0.125	1,000,000
20	2,000,000	0.500	1,000,000
50	800,000	1.250	1,000,000
0.2 v/cm	200,000	5.0	1,000,000
0.5	80,000	12.5	1,000,000
2	20,000	50.0	1,000,000
5	8,000	125.0	1,000,000
20	2,000	500.0	1,000,000

FIGURE 3-2. INPUT CHART

3-7. OPERATING CONTROLS

3-8. CHART-PWR SWITCH. Controls instrument power. It has three positions:

a. OFF-OFF: All power to the instrument is off.

b. OFF-ON: Power is applied to all electrical components except the AUTOGRIP system.

c. HOLD-ON: All electrical components of the instrument are energized, including the AUTOGRIP electric paper holddown.

3-9. PEN-TIME SWITCH. Governs the mode of the recording pen.

a. STANDBY: The pen is raised off the paper, chopper and motor reference phase is turned off. Used during paper loading.

b. UP-RESET: The chopper is energized and all other power is applied to the instrument. The recorder may be run through its complete range for adjustment of range and zero settings to accommodate the data to be recorded. The pen remains raised and no recording is made. When in TIME mode, the pen carriage is returned to zero (or start) following a sweep initiated by the RECORD-SWEEP position.

c. RECORD-SWEEP: The pen is lowered to the paper. Input data will cause the servo system to move the pen, creating the desired inked record. When in TIME mode, this position lowers the pen and initiates the sweep action.

3-10. FUNCTION SWITCH. Controls mode of X-axis range switch only:

a. VOLTS: Range switch selects normal voltage recording capability.

b. TIME: Range switch selects internally generated time sweeps. The RANGE calibrations in millivolts designate the sweep intervals in "seconds/division" (inch), or seconds/centimeter for the metric model.

3-11. RANGE SELECTORS. Both stepped and continuously variable controls are provided for each axis. The scale positions are calibrated in volts/division (inch) for the Model 2FRA and volts/centimeter for the Model 2FRAM. Below each selector knob is a FIX-VAR switch for selection of either fixed or variable range. In the "FIX" position, ranges are fixed and calibrated as marked; in the "VAR" position, the maximum voltage acceptance of any range setting can be continuously extended to several times the indicated fixed setting by a concentric knob on the RANGE selector. This feature is useful in fitting experimental data to any portion of the graph. The volts/division (inch) or volts/centimeter calibration, as determined by the position of these controls, does not change with the setting of the zero control. With the X FUNCTION switch in TIME, the millivolt readings of the X-Range selector indicate sweep speeds.

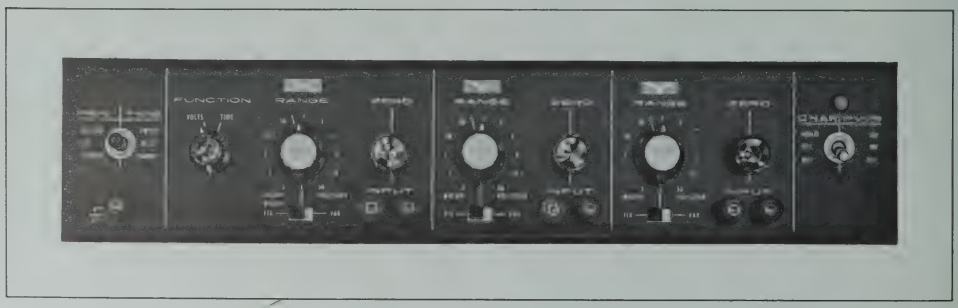


FIGURE 3-3. CONTROL PANEL

CAUTION: Input potentials should never exceed 750 volts on the X-axis or 500 volts on the Y-axes. The variable range extender is intended to increase the versatility of the instrument, not its maximum voltage range.

3-12. ZERO CONTROLS. Ten turn potentiometers on each axis permit placement of electrical zero anywhere on the paper, or suppression up to one full scale to the left and below the lower-left corner of the paper, regardless of the RANGE selector setting, Hence, through proper adjustment, data can be plotted in any desired quadrant.

NOTE: To prevent strain on the servo drives, the zero scale offset should be employed only to counteract a steady-state input which drives the graph toward full scale, or to reposition the minimum point at scale zero. It should not be used to establish the minimum point off the paper, causing the servo drives to exert a continuous force against the stop mechanism.

3-13. OPERATION PROCEDURE

3-14. CONDITIONS OF OPERATION. For satisfactory operation, the phenomena to be recorded must:

a. Be reduced to a DC current, the available voltage being a linear function of the original information.

b. Have amplitudes within the scale ranges of the recorder.

c. Vary in level within the response capabilities of the instrument.

3-15. DC OPERATION. Provided the above signal conditions are satisfied, the recorder may be placed in operation as follows:

a. Set the voltage conversion switch to a setting corresponding to the voltage available. For a 230 volt source, fuse should be 2 amperes; for 115 volts, 3 amperes. Connect power cord to power source, turn CHART-PWR switch to OFF-ON, and allow approximately ten minutes to reach a stabilized operating temperature.

b. Using a hypodermic syringe, inject a supply of recording ink into the pen reservoirs. Do not fill completely. Force ink into the pen tip by inserting an empty syringe into the filler opening and squeeze to apply air pressure.

c. Load paper as follows:

(1) Set the CHART-PWR switch to OFF-ON and the PEN-TIME switch to STANDBY.

(2) Install a sheet of graph paper on the recording platen, aligning lower left edges with corresponding table guides.

(3) Set CHART-PWR switch to HOLD-ON, thus activating the AUTOGRIP system. Adjust and smooth paper as necessary.

(4) Set PEN-TIME switch to UP-RESET.

d. Connect the signal voltages to be recorded to the input terminals and set the scale range selectors to the expected maximum values.

e. Data may now be dry run to insure adequate range and desired positioning on the paper. To record, set PEN-TIME switch to RECORD-SWEEP.

f. To establish accurate zero offset, connect a desired offset voltage to that axis and adjust the ZERO control to bring the carriage or pen index into exact agreement with the "0" mark on the corresponding scale.

3-16. TIME BASE OPERATION. The time base operates on the X-axis only. To record variable functions versus time, proceed as follows:

a. Prepare recorder and load paper as described in paragraph 3-15.

b. Set the FUNCTION switch to TIME.

c. Select the desired time sweep on the X-range switch.

d. Connect Y input data and select desired voltage ranges on Y range switches.

e. Position recording with range and zero controls. Dry runs may be made by removing pen from its carriage.

f. Set the PEN-TIME switch to UP-RESET.

g. Move PEN-TIME switch to SWEEP to actuate recording.

3-17. REMOTE CONTROL OF PEN-LIFT. When operating with accessory equipment it is often desirable to actuate the pen-lift mechanism from an external control. For convenience in this type of operation, a jack marked REMOTE-PEN is provided on the rear of the instrument. A contact closure applied to this jack will cause the pen to lower to the paper and remain down for the duration of the recording.

3-18. PEN ASSEMBLY. The assembly consists of a drum type reservoir resting in a pivot mount which moves along the carriage beam. A rigid capillary tube feed line leads from the reservoir to the pen point. The pen is raised from the paper by a lever system operated by an electromagnet to lower the pen to the paper.

3-19. OPERATING PRECAUTIONS

3-20. The CHART-PWR switch applies 115 volts, 60 cps power to the fixed phase windings of the three drive motors and the vacuum pump motor. Simultaneously, 6.3 volts is applied to the chopper. To

lower the power dissipation and avoid unnecessary wear to the balancing potentiometers, vacuum pump and other mechanical parts when not actually operating, the CHART-PWR switch should be set to OFF-ON and the PEN-TIME switch to STANDBY.

3-21. When a voltage in excess of the RANGE setting is applied to any one of the three sets of input terminals, the pen carriage or pen beam (depending upon the axis involved) will be rapidly driven full scale and strike the stops. If this condition prevails for any length of time, the high voltage may cause component failure. The motor will continue running due to a slip-clutch arrangement, resulting in motor overheating and excessive clutch wear.

3-22. Operation on the most sensitive input ranges from a very low impedance source such as battery or thermocouple voltages may require a reduction in gain to prevent instability. Refer to paragraph 5-13 for gain adjustment procedures.

3-23. Operation on the most sensitive input ranges with no input will result in relatively little to no "null." This can be overcome by shunting the input terminals with a 10K resistor. When an input is applied to the recorder, remove the shunt.

3-24. TYPICAL RECORDING PERFORMANCE. Figure 3-4 shows actual recorder performance. These curves were drawn on a normal production recorder. Lines 2, 3, and 4 were drawn by using a hand operated signal source similar to the test generator, figure 5-5. Curves 1 and 5 were produced by recording current vs voltage of a type 1N34 diode. All recordings of figure 3-4 show "original trace" and "retrace" characteristics. This clearly illustrates any servo dead zones or lag.

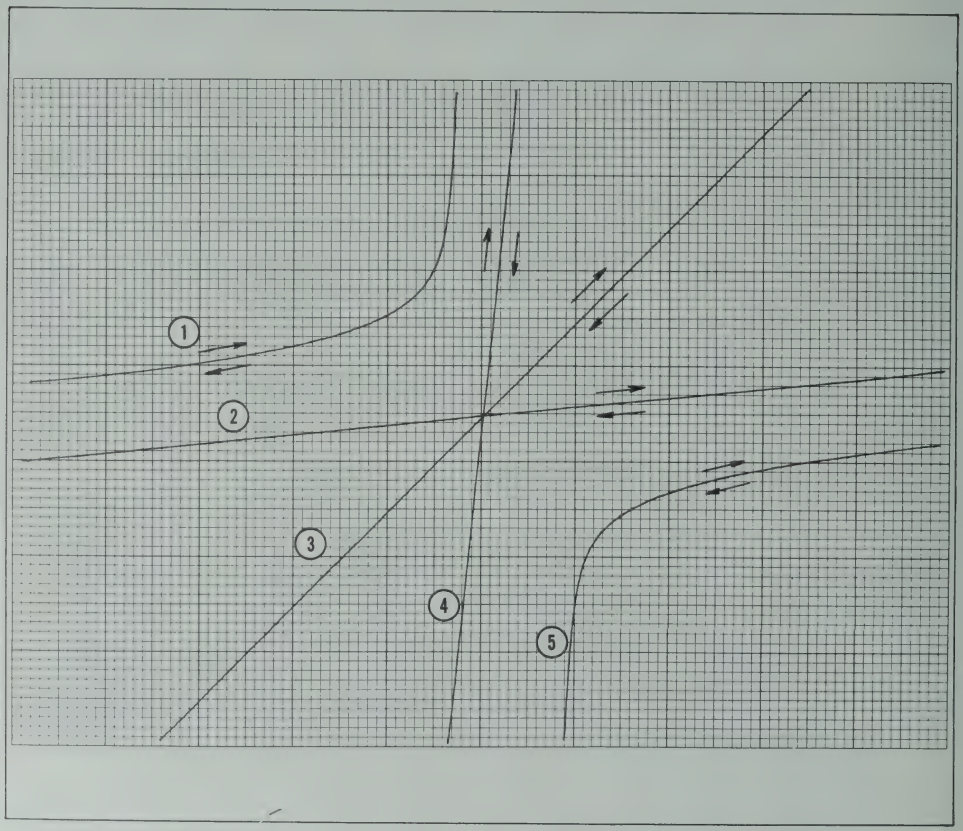


FIGURE 3-4. PERFORMANCE CURVES

SECTION IV
PRINCIPLES OF OPERATION

4-1. GENERAL OPERATION DESCRIPTION

4-2. SERVO MECHANISM. Models 2FRA and 2FRAM have three identical but independent self-balancing servo-mechanisms, isolated from ground. In operation, one servo-mechanism moves the entire carriage (including both pens) in a horizontal direction, and the other two servos move their respective pens in a vertical direction in response to input signals representing the data applied to the respective input terminals. The resulting relative motion of the servo-mechanisms traces cartesian coordinate graphs of the relationships on the paper.

4-3. FIXED AND VARIABLE RANGE CONTROLS. The basic voltage range of the servo systems is 0 to 5 millivolts DC for each Y-axis, and 0 to 7.5 millivolts DC for the X-axis. Operation with greater voltages is obtained by insertion of precision resistors in the balancing circuit. Each range step may be made continuously variable by operation of a transfer switch which inserts a variable potentiometer. Adjustment of this control increases the range span selected by the range selector so that an arbitrary voltage may drive the recorder pen to full scale. The range setting is selected to confine the input data within the travel limits of the instrument.

4-4. BALANCING ACTION. After passing through the attenuator, the input signal is applied to the balance circuit where it is cancelled by an internally supplied opposing voltage. Under these conditions, there is no signal output from the balance circuit and the servo system is at null. When the input signal changes to a new value, an unbalanced condition exists. The error signal (voltage difference) is applied to the chopper which converts the DC voltage to a 60 cycle AC form. The AC output of the chopper is amplified and applied to the control winding of a two phase servo motor. Due to mechanical coupling between the motor and rebalance potentiometer, the balance voltage changes value until it cancels the new input signal. If the input data is constantly varying at rates within the capabilities of the instrument, this rebalancing action is continuous. Therefore, the positions of the rebalance potentiometers and the pens are always directly proportional to the amplitudes of the signals at the respective input terminals.

4-5. TIME BASE. Use of the X-axis as a sweep circuit is determined by a function switch on the front panel. The time base operates on the principle that the charging current drawn by a capacitor will assume a constant value when the controlled charging voltage is increased at a uniform rate. With the addition of minor circuitry, existing facilities of the recorder are utilized to apply an increasing linear voltage to the X-axis servo amplifier causing the pen to advance at a uniform rate dependent on the constants switched into the circuit. The numerical values of the millivolt steps of the X-axis range selector represent sweep speeds.

4-6. CIRCUIT DESCRIPTION

The three axes use identical electronic circuits except for the addition of a time sweep circuit in the X-axis. Although the circuits are identical, certain component values may be varied slightly during manufacture to equalize the responses of the individual axes. Figure 4-2 is a simplified one megohm input circuit to aid in following the attenuator descriptions. Because the three axes are identical, circuit symbols refer to the Y_1-axis unless otherwise noted.

4-7. INPUT ATTENUATOR. Each pair of input terminals connects to a precision voltage divider which determines the maximum allowable input voltage range. The DC input attenuator is composed of four precision ±0.1% wirewound resistors. The resistors forming the attenuator in the Y_1 axis are R-101 through R-104. With the selector switch set to 0.5 millivolt/division (0.2 millivolts/centimeter in the metric unit), the input voltages are applied across a resistance of one megohm and proceed to the balance circuit without attenuation. The voltage

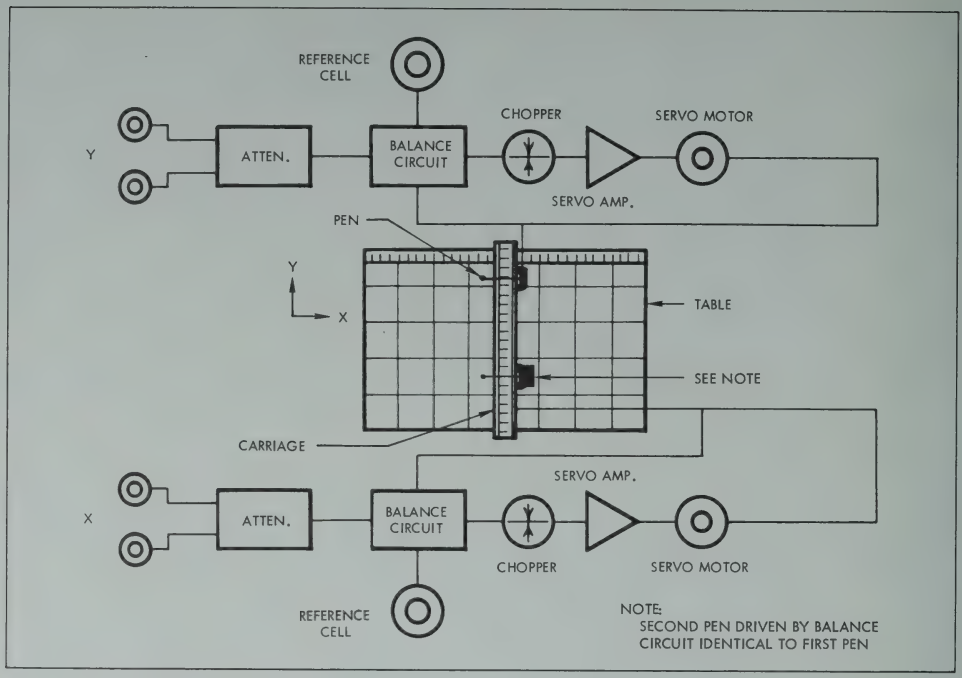


FIGURE 4-1. BLOCK DIAGRAM

in the balance loop is varied by resistors R-107, R-109, and R-110. This allows a signal up to 10 millivolts/division (5 millivolts/centimeter in metric unit) to be applied to the balance circuit without prior attenuation. Input signals greater than this must be attenuated before reaching the balance circuit. The attenuator switch S-101 selects the correct balance resistor for each input range.

4-8. VARIABLE RANGE CIRCUITS. With the FIX-VAR switch S-103 set to VAR, the input voltages are routed through the variable range circuit. This consists of potentiometer R-105 and resistor R-106. Extension of the fixed ranges is effected by varying R-105. No attenuation is inserted by the variable range circuit when operating in the FIX position.

4-9. REFERENCE SUPPLY. The reference voltage for each axis is independently derived from a zener controlled DC power supply, nominally 9V, stable to 0.03% with line variation of ± 10%. The primary of transformer T-801 is supplied with 115 VAC. The rectified output from diodes CR-811 and CR-812, filtered by C-803 and R-808, is applied to zener diode CR-810 which is of high regulating ability. CR-810 reduces the line voltage variation which may appear in the rectified output. Diode CR-809 is a zero temperature coefficient zener diode which further regulates the output of the previous stage for greater precision. This diode is operated at current and voltage levels to provide temperature compensation for the reference supply. Rheostat R-119 is the DC calibration control for the Y_1 axis. The calibrate voltage appearing across the rebalance potentiometer R-801 is adjusted so that the Y_1 servo balances at full scale with 5.0 millivolts.

4-10. BALANCE CIRCUIT. The DC input signal, after passing through the attenuator, is applied to the balance circuit where it is opposed by a DC cancellation voltage from the internal reference supply. The difference between these two voltages, or error signal is converted to AC by a chopper and applied to one winding of the servo motor. The servo motor, M-902, being mechanically coupled to the rebalance potentiometer R-801, drives this potentiometer in a direction to cause the opposing reference voltage to equal and thereby cancel the error signal. The pen, being directly connected to the potentiometer, will move in direct relationship with the error signal until the circuit is balanced and the pen is at null. A ten tune potentiometer, R-117, provides zero control for the Y_1 axis. This potentiometer introduces into the balance circuit a "controlled" error signal which is cancelled in the same manner as an input error signal. This provides a means for placing electrical zero anywhere within the graph limits.

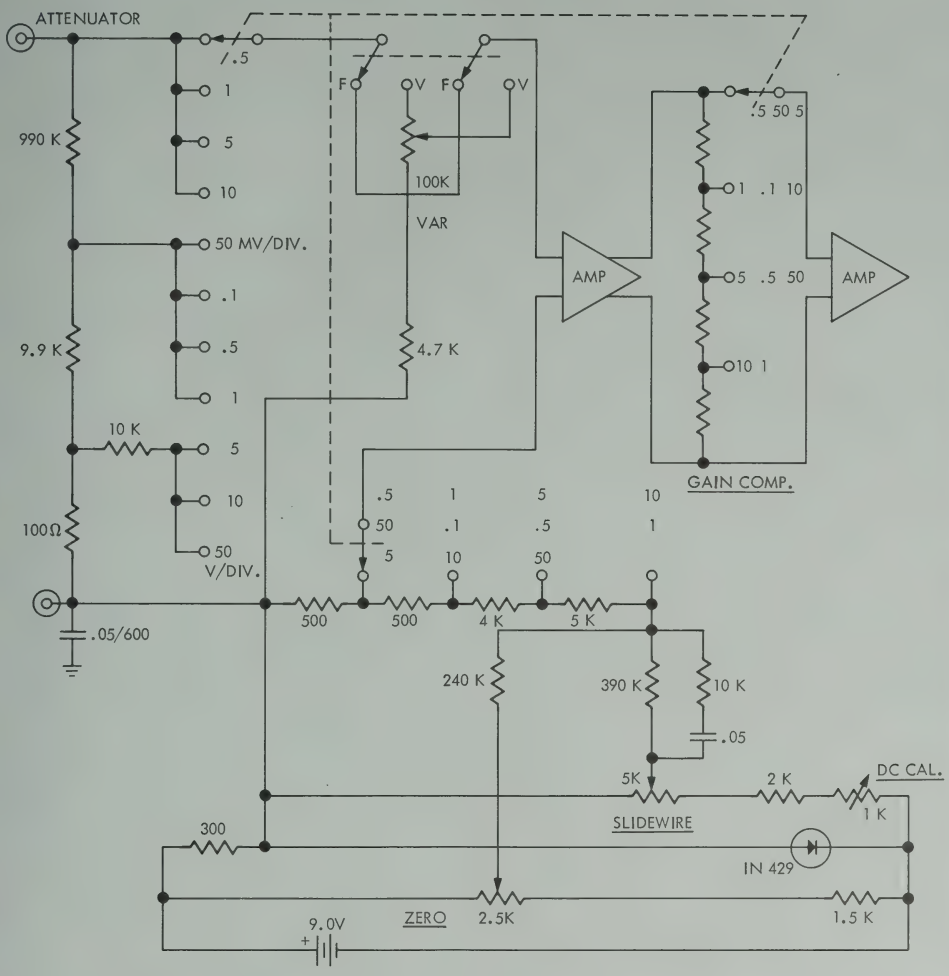


FIGURE 4-2. ONE MEGOHM INPUT CIRCUIT

4-11. CHOPPER AND INPUT TRANSFORMER. The error signal is converted to 60 cps (or 50 cps depending upon the power source) AC by the chopper. As the chopper is driven in synchronism with the power line, the output from the input transformer will be either in phase or 180 degrees out of phase with the line voltage (disregarding chopper lag). Phase relationship is dependent upon the polarity of the DC error signal. The direction of servo motor rotation is determined by the relative phase excitation of its two windings causing the motor to drive the pen and coupled potentiometer in a balance seeking direction. A voltage gain of about 13 is realized in transformer T-501. Under normal operating conditions the magnitude of the error signal never exceeds 5 millivolts in Y or 7.5 millivolts in X and, as the system is sensitive to approximately 0.1% of this voltage, it is evident that the error signals can be exceedingly small, actually in the microvolt region. Because of this, all input circuitry is carefully engineered to minimize interference from stray hum pickup and thermal emfs.

4-12. 1ST, 2ND AND 3RD VOLTAGE AMPLIFIER STAGES. Adequate voltage amplification is provided for the power stages by Nuvistor V-501 and transistors TR-501 and TR-502 in a conventional cascade circuit. Nuvistor V-501 adds needed amplification for the one megohm input condition without increasing background noise. Feedback is supplied from the emitter of TR-502 through R-543 to the base of TR-501. Diodes CR-503 and CR-504 protect TR-501 and TR-502 against overload.

4-13. PHASE INVERTER. The output of the third amplifier stage is coupled to the phase inverter section by C-505. Phase inversion is accomplished in the following manner. A decreasing voltage applied to the base of TR-503 causes a rising voltage to appear at the collector. At the same time, the emitter tends to follow the base potential, i.e., decrease. Since the base of TR-508 is effectively at AC ground potential, the effect of the decreased emitter signal at TR-503 is a rising signal at the collector of TR-508. The overall effect is to produce amplification and phase inversion to the output of TR-502.

4-14. POWER AMPLIFIER STAGES. The push-pull amplifier consisting of TR-504 and TR-507 operates in phase opposition to drive the output transistors TR-505 and TR-506 through transformer T-502. These latter transistors supply power to the servo motors. The major feed-back loop is composed of resistors R-527, R-526 and capacitors C-507, C-512. Sufficient phase change is introduced so that when the phase lag of the chopper is added, the output control voltage to the servo motor is approximately 90° out of phase with the reference winding of that motor.

4-15. POWER SUPPLY. CR-511, CR-512, and C-514 constitute a half-wave rectifier and filter. TR-509 is a series regulator controlling current through voltage divider R-532 and T-531. TR-509 is stabilized by TR-510 whose base is controlled by zener diode CR-509. CR-509 also insures accurate and stable potentials for the low level amplifier stages. Filtered filament voltage for the Nuvistor stages is taken from the half-wave rectifier section and controlled by zener diode CR-501.

4-16. TIME BASE. Available on the X-axis only, this circuit operates on the principle that the charging current to a capacitor remains constant as the charging voltage increases at a uniform rate. By addition of minor circuitry to that existing on the X-axis, the requirements for the time sweep are satisfied. Figure 4-3 is a simplified time base circuit to aid in following the operational description. Circuit symbols correspond to those used on the Model 2FRA schematic (MD-12607) found at the end of this manual.

a. Sweep speeds are determined by the balance voltage. This voltage is provided by the Y-axis balance circuit and attenuated by the sweep range attenuator composed of resistors R-312 through R-321. The voltage drop developed across the charging resistor R-318 or R-319 by the charging current of capacitor C-303 or C-304 is partially cancelled by the preselected balance voltage. The voltage difference is applied to the servo amplifier with the polarity necessary to drive the pen up scale. The balance potentiometer, R-802, being coupled to the pen, will also be driven up scale resulting in a further increase in the charge on capacitors C-303 and C-304 and hence the charging current. This increase tends to balance the decreasing charging current encountered under constant voltage conditions.

b. As there is always a small mismatch between the voltage drop across R-318 or R-319 and the balance voltage, the time sweep action will continue until the RECORD-SWEEP switch, S-901, is closed. When closed, the amplifier input is connected to the X-axis zero control circuit. The zero control potentiometer, R-324, allows positioning of the sweep starting position anywhere on the X-axis. Opening of switch S-901 initiates the timing action just described by eliminating the zero positioning voltage from the circuit. This allows the unbalanced error voltage across R-324 to be applied to the amplifier. An error rate damping network for the input to the servo amplifier is provided by R-336, R-337, C-306 and C-305.

4-17. DAMPING. Capacitor C-103 draws a charging current whenever a change in input occurs, thereby increasing the rate of appearance of the balance voltage across resistor string, R-107, R-109, and R-110. This phase advance in the slowly varying error signal causes an "anticipatory" approach to the balance point, producing damping.

4-18. MOTOR AND MECHANICAL DAMPER. The X and Y_1 servo motors are Moseley 2-phase induction types. The Y_2 servo motor is a 2-phase Daystrom Transicoil, Type 15. One phase is energized from the AC power line, the other being excited in phase quadrature from the amplifier output. Direction of motor rotation is determined by whether a leading or lagging 90° phase relationship exists. A pinion on the motor shaft meshes with a large aluminum gear which is coupled to the drive sheave through a friction

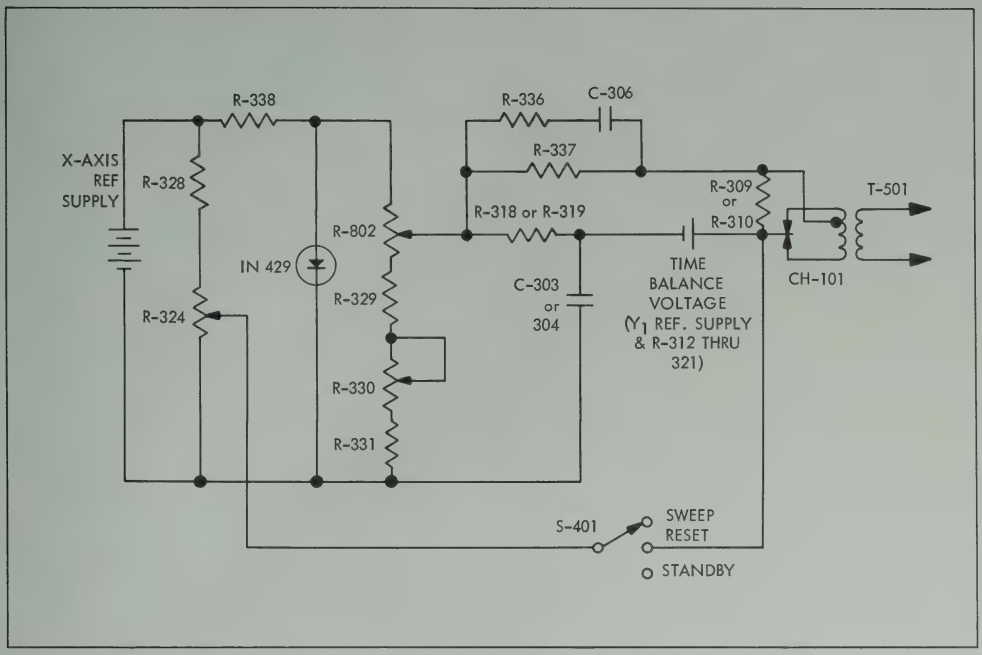


FIGURE 4-3. SIMPLIFIED TIME BASE CIRCUIT

clutch. A mechanical inertia damper is mounted on the opposite end of the armature shaft. Sealed inside the outer case is a metallic mass in viscous silicone oil which damps the operating characteristics of the drive motor, producing a smooth trace when recording.

4-19. AUTOGRIP PAPER HOLDDOWN. This exclusive feature consists of a completely sealed specially constructed platen with integral power supply which develops a strong electrostatic field over the entire table surface. Firm gripping power is efficient on any size graph paper up to the actual size of the platen.

4-20. PEN SYSTEM. The standard pen consists of a metal reservoir, transfer tube, and pen tip. The pen is filled and primed with a syringe supplied in the accessory kit. Once primed the ink will continue to flow through capillary action as used at the pen tip. Because of the capillary process, rack mounted (vertical) models write equally as well as the table models.

SECTION V
MAINTENANCE

5-1. PREVENTIVE MAINTENANCE

5-2. GENERAL. The Model 2FRA must be maintained properly to give accurate, trouble-free operation. This requires periodic lubrication, performance tests, visual and electrical checks. Moseley recorders should always be protected from dust by covering when not in use.

5-3. ENVIRONMENTAL OPERATION. This recorder is not designed to operate under extreme cold or heat conditions. Such operation will produce inaccurate results and may cause permanent damage. In areas with high humidity, graph paper may become stretched with resulting distortion of the grid lines. Operation under conditions of excessive air contamination (soot, smoke, fumes, etc.) will require more frequent cleaning maintenance.

5-4. CLEANING. Thorough cleaning should be performed periodically. Required intervals are determined by the type of operation, local air contamination, and climatic conditions. Under normal use and conditions, routine cleaning should be accomplished every nine to twelve months. To clean the instrument, proceed as follows:

a. Remove the control box, platen, amplifier, and all dust covers.

b. In hard-to-reach areas and where there is only dust accumulation, cleaning can be accomplished with an air gun. In more accessible areas and where the air gun will not remove the dirt, dust, or ink, a cloth or sponge saturated with plain soap and water should be used, then wiped clean with a dry cloth.

c. Bearings (except clutch bearings), gears, and other lubricated components should first be cleaned thoroughly with a solvent and relubricated every eighteen to twenty-four months. Soap and water should not be used on these parts.

d. The platen surface should be cleaned with a compound such as Jet Spray, Bon Ami, or Ajax. These are especially effective in removing dried ink.

WARNING: Use of cleaning solvents of any type should be avoided on the AUTOGRIP platen.

e. Cleaning of pen and slidewires are described under separate headings in the mechanical maintenance section.

5-5. LUBRICATION. The Model 2FRA is a precision instrument with bearings, gears, and other moving parts having very close tolerances. For this reason lubrication should be performed with caution. Over lubrication may produce more friction than a very little. Recommended intervals are determined by type of operation, local air contamination and climatic conditions. Under normal use and optimum conditions every nine to twelve months is adequate. A complete routine including cleaning should be performed at least every two years. A suggested lubrication procedure follows:

1. Do not attempt to clean or lubricate the sealed clutch bearings, or the slider arm which is an oil impregnated bronze bushing.

2. Apply a thin film of Aeroshell Mil-G-7118A or equivalent on the X and Y gear drives (including idler gear).

3. Apply a drop of LO-17 Stanoil #35 or equivalent to the four X axis drive pulley bearings.

4. Servo motor bearings should be lubricated with a drop of Penn-Motor Oil #40 or equivalent. Lubrication of these bearings requires disassembly of the servo motor.

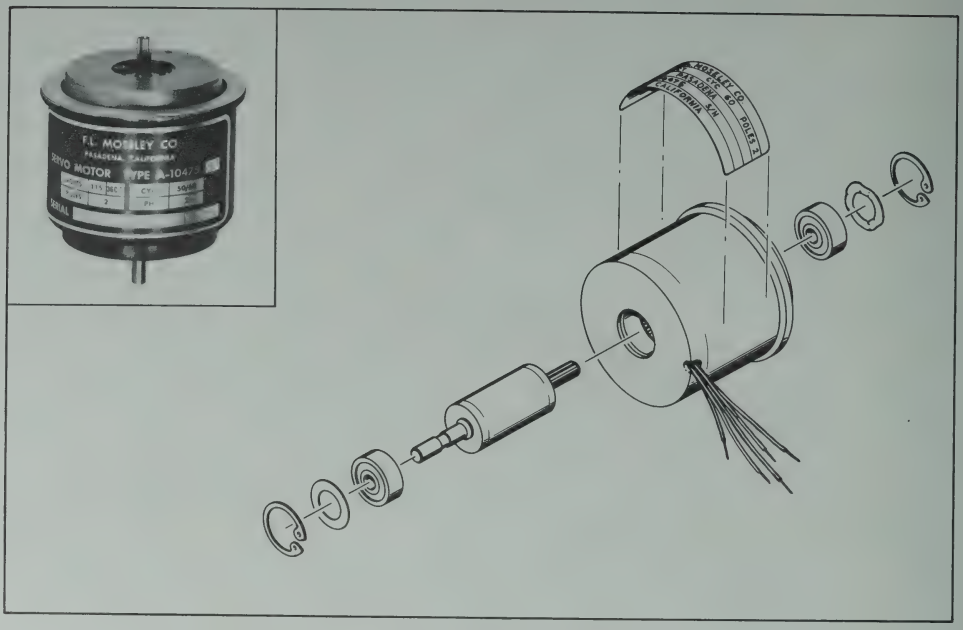


FIGURE 5-1. SERVO MOTOR ILLUSTRATION

CAUTION: Because of very small air clearance between rotor and stator any oil seeping into this area will impair motor operating characteristics.

5. Lubricate springs inside each of the pantograph arms with Plastic Lub # 00 (all purpose), or equivalent.

6. Apply a drop of Stanoil #35 to the three joints and bearings of the pantograph arm. No lubricate is required on the slider rod.

7. Lubricate the two Y-axis drive pulleys with a drop of LO-17, Stanoil #35, or equivalent.

CAUTION: Oil must be prevented from dropping on either slidewire. If it does, the slidewire must be thoroughly cleaned with a solvent.

5-6. VISUAL INSPECTION. During periodic cleaning and lubrication, a routine visual inspection should be performed. Following is a general guide which should not be considered to restrict inspection of other obvious items.

1. Check the X, Y_1 and Y_2 drive gears for proper adjustment (a slight amount of backlash), and any worn or damaged teeth.

2. Inspect X-axis drive cable pulleys and X-axis pantograph arm for any binding.

3. Insure that all servo motors are mounted securely and mechanical dampers are firmly secured to the motors.

4. Tighten mounting screws on the amplifier and any optional plug-in units to insure good electrical contact.

5. Move both pen carriages up and down (independently) listening for scrapes, grinding noises, etc., while feeling for any binding in the movement. Repeat with the carriage arm.

6. Check all axes for fraying or rubbing of drive cables.

7. Component check should include inspection for evidence of overheating, loose connections, broken circuit boards, etc.

5-7. ELECTRICAL MAINTENANCE

5-8. TROUBLE SHOOTING. The concept of "bracketing," i.e., establishing circuits or sections which are not operating at all, or are operating abnormally, is generally the fastest way to locate trouble in a closed loop circuit. Many malfunctions, other than those caused by improper adjustments, may be localized by reference to the Trouble Shooting Chart, Figure 5-11.

5-9. CALIBRATION. Calibration is standardized during manufacture against a Weston Standard Cell. The electronic reference is designed to have negligible drift. Should a long term drive be noted due to a possible change in value of components, recalibration may become necessary. The following procedure should be used:

a. For access to all calibration controls and the input circuit board, pull the control box forward and remove the bottom cover plate.

b. Completely energize the recorder and allow approximately ten minutes to reach a stabilizing temperature.

c. Set the FIX-VAR switches to FIX and the RANGE switches to 0.1 volt/division (50 mv/cm on metric model).

d. Connect an accurately established one volt DC source (as obtained, for example, from an L & N precision potentiometer and Weston Standard Cell) in correct polarity to the input terminals of all three axes (X, Y_1, Y_2). This voltage should drive the carriage and both pens to the upper right portion of the paper.

e. Remove the warning cover and adjust appropriate controls to bring both pens into exact agreement with the "10" mark on the X and Y scales. Removal of the signal should cause the pens and carriage to return to the "0" mark on the scales. Repeat procedure until accurate repositioning is achieved.

f. In the event "10" cannot be reached by adjustment of the calibration controls, the electronic reference supply should be checked for an output of 9.0V (±5%).

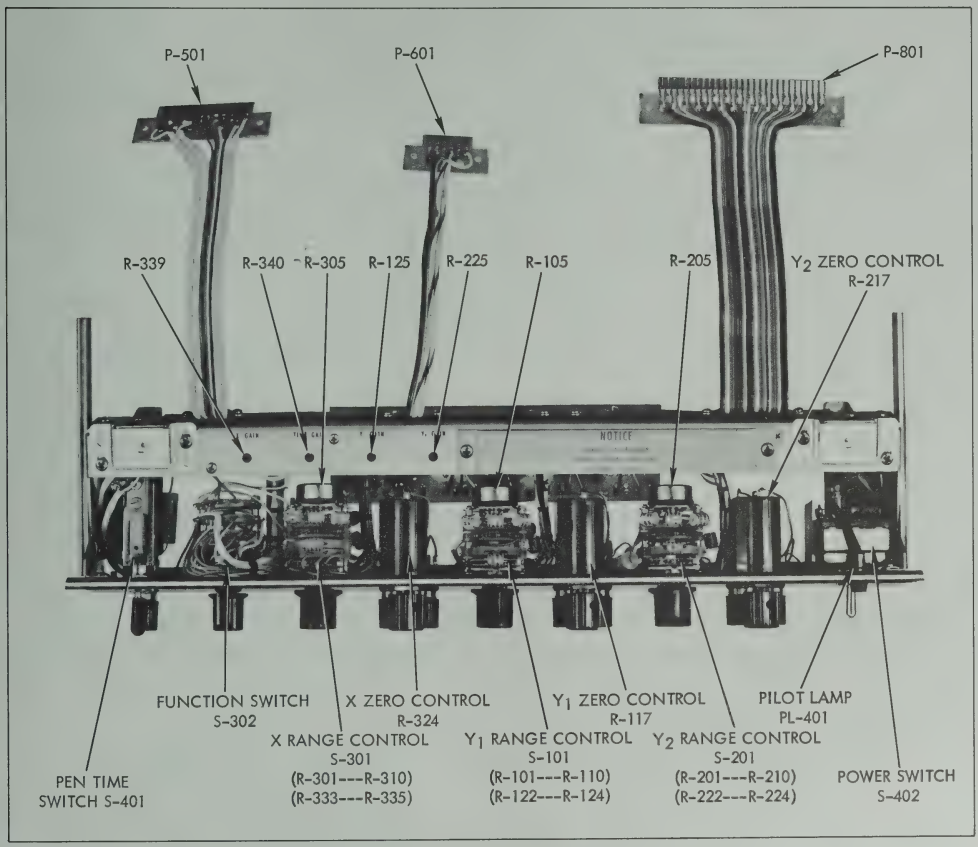


FIGURE 5-2. CONTROL BOX (TOP VIEW)

5-10. TIME BASE CALIBRATION. The various sweep speeds are established during manufacture by special component selection for each instrument and normally will not change appreciably. If recalibration is required due to excessive deviation from the fixed speeds, allow recorder sufficient time to reach a stable operating temperature (approximately ten minutes) and proceed as follows:

a. Check timing accuracy for the 50 seconds/division (20 seconds/cm) speed by using stop watch.

b. If deviation in (a) is greater than ±2.5 seconds/division (1.0 second/cm), recalibration requirement is indicated. For this purpose an accurate time function generator should be available for application to the Y-axis for comparison to the actual X-axis advance. Either Y-axis may be used but the one chosen should be used throughout subsequent calibration procedure.

c. Moderately accurate overall timing calibration may be accomplished by adjusting three potentiometers on the top of the control box (see figure 5-2).

(1) DC calibrate and adjust TIME-GAIN control R-340.

(2) Adjust R-320 (HI) for simultaneous control of first two sweeps.

(3) Adjust R-321 (LO) for simultaneous control of last three sweeps.

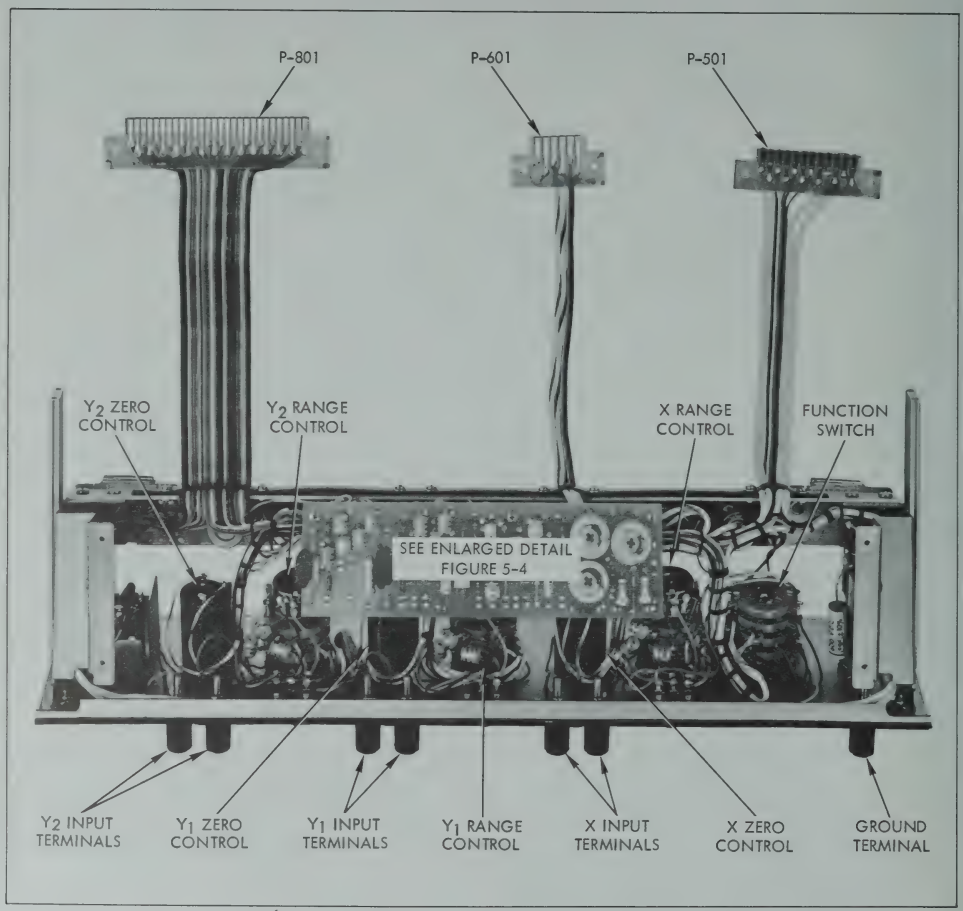


FIGURE 5-3. CONTROL BOX (BOTTOM VIEW)

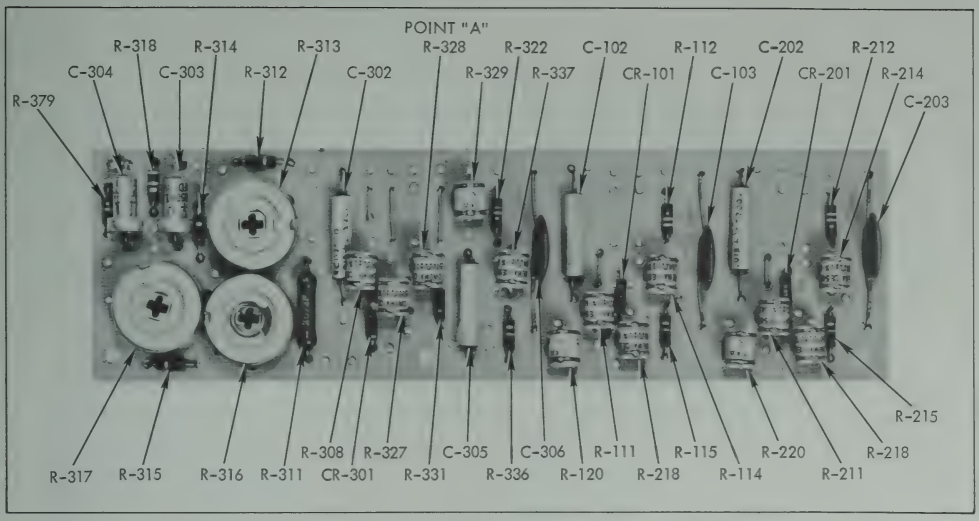


FIGURE 5-4. PRINTED CIRCUIT BOARD (CONTROL BOX)

d. If step (c) is inadequate, complete recalibration is indicated. As the additional potentiometers involved are set and sealed during production, detailed calibration should not be attempted unless absolutely necessary and then only by using an accurate time function generator and proceeding in the following sequence:

(1) Adjust R-320 for 0.5 seconds/division (0.2 seconds/cm).

(2) Adjust R-313 for 1.0 seconds/division (0.5 seconds/cm).

(3) Adjust R-321 for 5.0 seconds/division (2.0 seconds/cm).

(4) Adjust R-316 for 10 seconds/division (5 seconds/cm).

(5) Adjust R-317 for 50 seconds/division (20 seconds/cm).

NOTE: Potentiometers R-313, R-316 and R-317 are grouped together on a printed circuit board on the bottom of the control box.

e. Trouble shooting of the time base may be greatly simplified by referring to Schematic C-13714 which depicts only the time base circuit.

5-11. DAMPING. No damping adjustments are required due to use of a fixed damping circuit. Refer to paragraphs 4-17 and 4-18 for description.

5-12. PERFORMANCE CHECKING. A convenient method for checking overall performance is to apply a smoothly varying DC voltage to two pairs of the input terminals (X and Y) or (X and Y_2) simultaneously. A simple test generator for this purpose may be constructed as illustrated in figure 5-5. If the generator control knob is rotated CW to draw a line and then CCW to draw back along the same line, the result is called a "retrace" curve. The space, if any, between the up-line and the down-line is the "retrace error." The amount of retrace error is governed by the gain setting, damping, and servo system friction and backlash. A correctly operating instrument will exhibit practically zero retrace error. The straightness of the line drawn in this manner is a measure of linearity. A loose pen or carriage system will result in a rough trace; a defective or worn rebalance potentiometer will cause a curved trace.

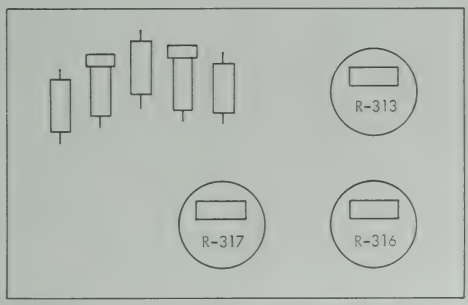


FIGURE 5-5. CALIBRATION POTENTIOMETER LOCATION CHART

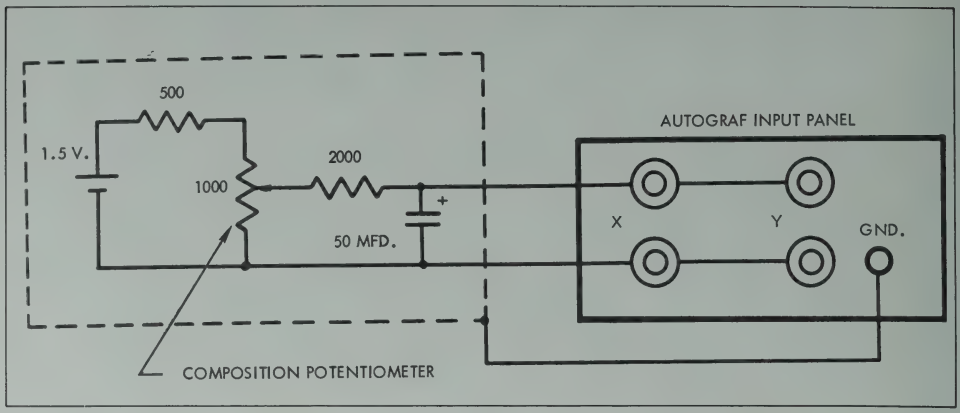


FIGURE 5-6. TEST GENERATOR

5-13. GAIN ADJUSTMENTS. Gain potentiometers are screwdriver adjustments located on the top of the control box. Pull control box forward and adjust as follows:

a. Set the gain potentiometers to a minimum position (fully CCW).

b. Connect Test Generator to two axes as in paragraph 5-6, above.

c. Set the recorder RANGE switches on each axis to 0.1 volt/division (50 mv/cm) for X, and 0.5 volts/division (0.2 volt/cm) or Y_1. Rotation of the test generator control will cause a nearly horizontal line to be drawn. Any retrace error will be due largely to low gain in the Y_1 axis. Adjust the Y_1 gain control for as close to zero retrace as possible. Repeat this procedure for Y_2.

d. Set the RANGE switches to 0.5 volts/division (0.2 volt/cm) on X, and 0.1 volt/divison (50 mv/cm) on Y (either Y may be used). Applying a test signal will cause a nearly vertical line to be drawn. Any retrace error will be due to low gain in the X-axis. Adjust the X gain control for as close to zero retrace as possible.

e. Generally, an optimum setting of the gain controls will produce essentially zero retrace.

5-14. After the X and both Y axes have been optimized for minimum retrace error independently, set both RANGE switches of a pair of axes to identical values. Apply the voltage obtained from the Test Generator to the X and Y_1 axes (either Y-axis may be used). A straight line of 45 degree angle will be produced. Assuming the retrace test demonstrates essentially zero retrace error, or approximately the same error in both axes, any space appearing between the 45 degree lines will be due to a phase difference or time lag between the two recording axes. Phase adjustment is accomplished by altering the value of filter capacitor C-103, C-203 or C-306. If these capacitors are found to be other than 0.05 mfd, phase adjustments were made during manufacture.

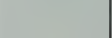
Incorrect		Correct
	Set X on 0.1 v/in. range. Set Y on 0.5 v/in. range. Rock potentiometer control of tester back and forth. Poor retrace indicates insufficient gain in Y channel. (To check X channel, set X to 0.5 v/in.; Y to 0.1 v/in.)	
	Use same settings as above. Rough writing indicates too much gain in axis being tested.	
	Use same settings as above. Roughness appearing in one part of trace is probably due to a worn or dirty balance potentiometer.	
	Use same settings as above. Three cyclic variations in trace indicate gear train mesh is too tightly adjusted.	
	Connect a 1-1/2 volt battery to the Y input. Leave X input open. Slowly rotate zero control while rapidly flipping the Y attenuator knob between 0.5 and 1.0 v/in. positions. Excessive overshoot and oscillation indicates too much gain in Y axis. Repeat for X axis.	

FIGURE 5-7. PERFORMANCE CHART

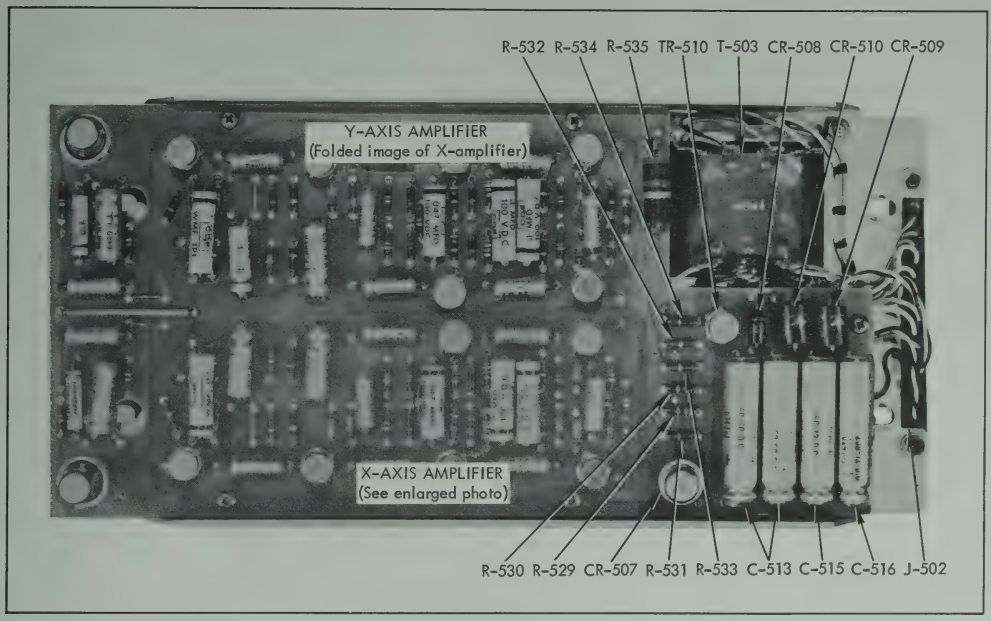


FIGURE 5-8. X-Y AMPLIFIER (BOTTOM VIEW)

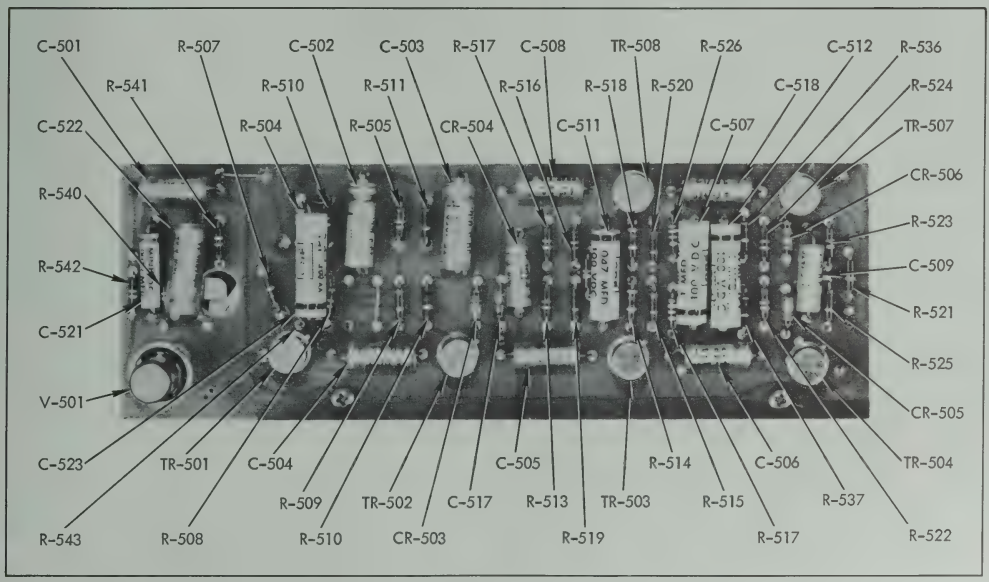


FIGURE 5-9. X-AXIS PRINTED CIRCUIT BOARD

5-15. SERVO STANDBY VOLTAGE. A recorder which is performing properly will have a low "standby" voltage supplying each of its servo motors. This may be checked by placing an AC voltmeter between the collectors of output transistors TR-505 and TR-506. This is equivalent to placing the voltmeter across the control phase winding of the servo motor. A normal standby voltage will range between 3 and 5 volts. If the pen carriage is manually forced from null, the standby voltage will rise rapidly to about 30 volts. At about 15 volts the drive clutch will slip, accompanied by a whirring sound.

5-16. TROUBLE SHOOTING. The following difficulties, other than malfunctions caused by improper adjustment, may be localized by reference to the TROUBLE SHOOTING CHART, figure 5-11.

5-17. LINEAR POTENTIOMETER MAINTENANCE. Irregular or rough plots produced by smooth signals on a properly adjusted recorder indicate a possible worn or dirty rebalance potentiometer. The resistance wire mandrel of the potentiometer may be cleaned with a moderately stiff brush using gentle strokes at right angles to its length, i.e., parallel to the individual turns of fine wire. Care should be exercised during this operation to prevent damage to the fine wire. The solid return wire may be cleaned with a lint free cloth moistened slightly with a solvent, such as Moseley Contact Cleaner Type 391-0001 which leaves no greasy residue. The sliding contact should be adjusted to about a 45 degree angle before installation. Correct contact pressure is approximately 15 grams.

5-18. POTENTIOMETER REPLACEMENT. Under paragraph 5-12 a test is described for checking the rebalance potentiometers. If replacement is indidated, complete assemblies should be obtained from the factory. The following replacement procedures are for earlier models equipped with the "round" mandrel. The present models are equipped with flat mandrel rebalance potentiometers which are permanently fastened to the carriage beam. Replacement of these later potentiometers require replacing the carriage beam assembly. Refer to paragraph 5-25.

a. Y_1-AXIS REBALANCE POTENTIOMETER. This assembly is mounted under the lower carriage beam.

(1) Remove the Y_2 carriage beam (see paragraph 5-26a).

(2) Remove the Y_1 carriage beam (see paragraph 5-26b).

(3) To remove the pen carriage, loosen the two screws in the rollers on the pen tip side. Turn the eccentrically mounted rollers with a stiff wire until the holes are closest to the carriage beam. Slip the nylon cord off the lower pulley.

(4) Unsolder the three wires connected to the potentiometer, noting the color coding to insure correct installation of the new assembly.

(5) Remove the three machine screws holding the potentiometer to the carriage beam.

(6) Install the new potentiometer unit and reassemble.

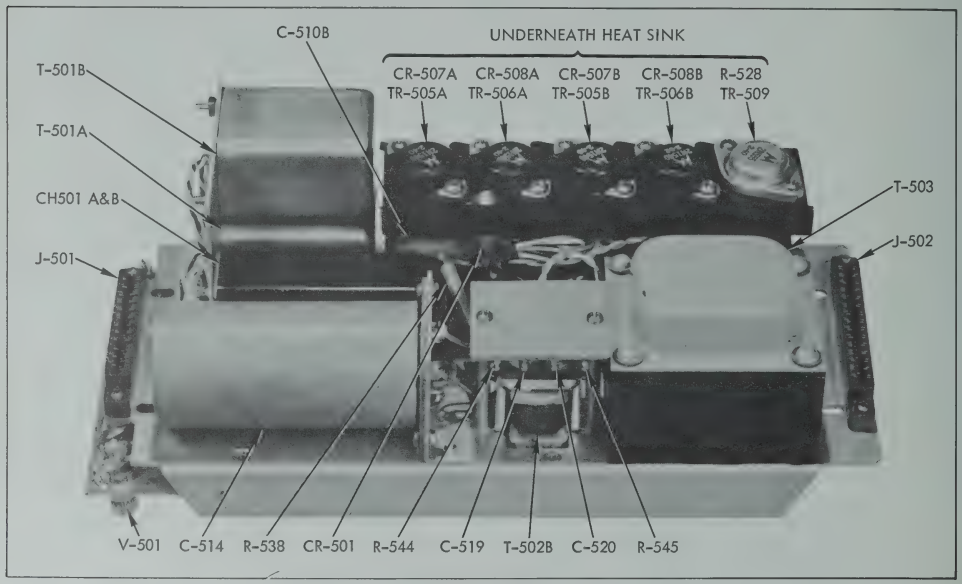


FIGURE 5-10. X-Y AMPLIFIER (TOP VIEW)

b. Y_2-AXIS REBALANCE POTENTIOMETER. This assembly is also mounted under the lower carriage beam.

(1) Remove the Y_2 carriage beam (see paragraph 5-26a).

(2) Perform same operations as for replacement of Y_1 potentiometer.

c. X-AXIS REBALANCE POTENTIOMETER. This assembly is mounted behind the rear panel of the recorder.

(1) Remove the top trim strip, mounted by two machine screws.

(2) Remove the top cover, mounted by four machine screws.

(3) Unsolder the three wires on the right side of the potentiometer noting the color coding to insure correct installation of the new assembly.

(4) Remove the five machine screws holding the potentiometer mounting strip to the frame, also the four screws holding the potentiometer to the mounting strip.

(5) Install the new potentiometer unit and reassemble.

INDICATION	PROBABLE CAUSE	LOCATING CAUSE
1. Sluggish response of zero controls on 4 most sensitive ranges.	1. This condition is normal with no input applied. Short circuit input for normal response (MAX. SOURCE RESISTANCE 50K).	1. N/A
2. Noisy, or rough trace.	1. Instrument not grounded.	1. 115/230 VAC POWER GND. REQ.
	2. Worn or dirty potentiometer.	2. See paragraphs 5-17 and 5-18 for tests and corrective procedures.
	3. Insufficient contact pressure or improper positioning of wiper on slidewire balance potentiometers.	3. Contact at 45° angle before installation with contact pressure of 15 grams (approximate values).
	4. Noisy nuvistor or transistors in amplifier. (Microphone input trans. possible cause.)	4. Check amplifier output transistors, if noise is present check plate of nuvistor. This will localize the trouble to a few components.
	5. Backlash adjustment incorrect.	5. See paragraph 5-26 for desirable setting.
	6. Regulator zener diode for nuvistor filaments defective.	6. Check filament circuit.
3. Dead zone, manifested by inability to obtain an acceptable retrace and/or poor damping.	1. Friction in mechanical linkage.	1. Inspect all moving parts, pantograph arm, gears, bearings, etc.
	2. Loss of voltage gain due to defective component.	2. Check each amplifier stage and the power supply.
	3. Unbalanced output transistors, TR-505 and TR-506.	3. Check the waveforms of each output transistor. Both points should produce identical waveforms.

FIGURE 5-11. TROUBLE SHOOTING CHART (Sheet 1 of 2)

INDICATION	PROBABLE CAUSE	LOCATING CAUSE
4. Sweep velocity decreases and appears non-linear. NOTE: Sweep runs backwards. See cause #3.	1. Low servo gain or loss of gain resulting in loss of hull.	1. Check the amplifier output and the reference supply.
	2. Friction in mechanical linkage.	2. Inspect all moving parts, pantograph arm, gears, bearings, etc.
	3. Leakage in the 5 and 30 mfd tantalum capacitors.	3. Replace.
5. Interaction between axes.	1. Unbalanced output transistors, TR-505 and TR-506.	1. Check the output transistors of each axis, both should produce identical waveforms.
	2. Microphonic nuvistor or input transformer in amplifier stage.	2. Check the signal at the plate of the nuvistor.
	3. Failure of low voltage supply regulators.	3. Check the power supply outputs.
	4. Chopper malfunctioning.	4. Check the signal at the plate of the nuvistor.
	5. Defective REGULATOR ZENER DIODE FOR NUVISTOR FILAMENTS.	5. Check the nuvistor filament circuit.
6. Loss of Vacuum Hold-down on models without AUTOGRIP.	1. Obstruction in intake line.	1. See paragraph 6-11 for complete vacuum system maintenance.
	2. Clogged filter.	2. See paragraph 6-11.
	3. Pump failure.	3. Same as No. 1
	4. Leak at O-ring seal (platen and vacuum line).	4. a. Tighten platen screws. b. Replace O-ring.
	5. Broken V-belt.	5. Visual inspection.
	6. Motor inoperative.	6. Visual inspection.

FIGURE 5-11. TROUBLE SHOOTING CHART (Sheet 2 of 2)

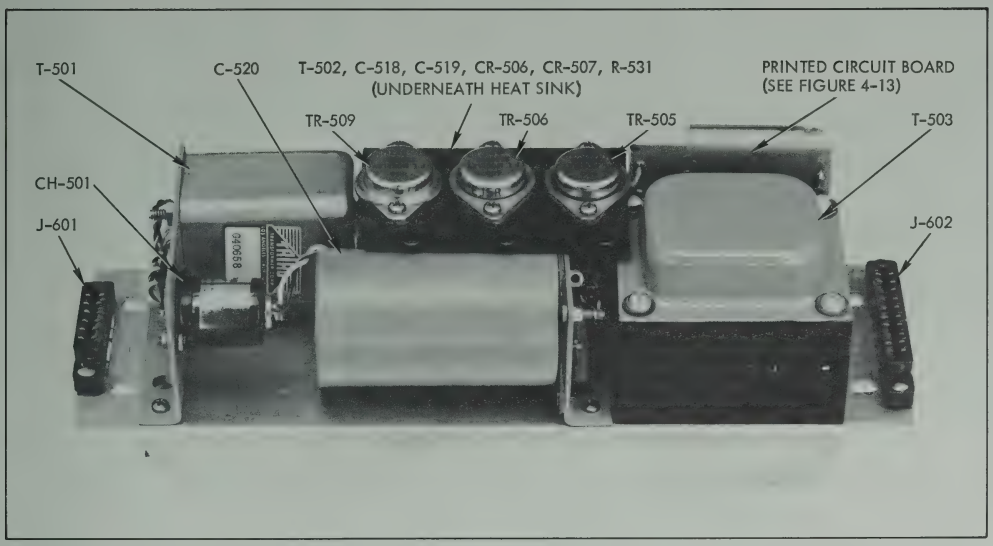


FIGURE 5-12. Y_2 AMPLIFIER (TOP VIEW)

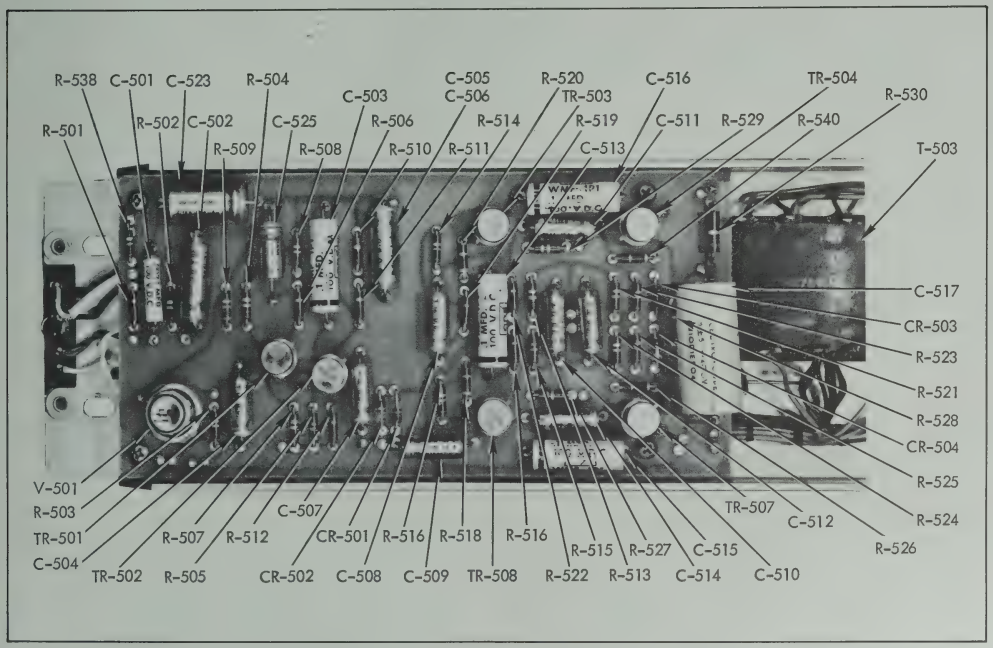


FIGURE 5-13. Y_2 PRINTED CIRCUIT BOARD

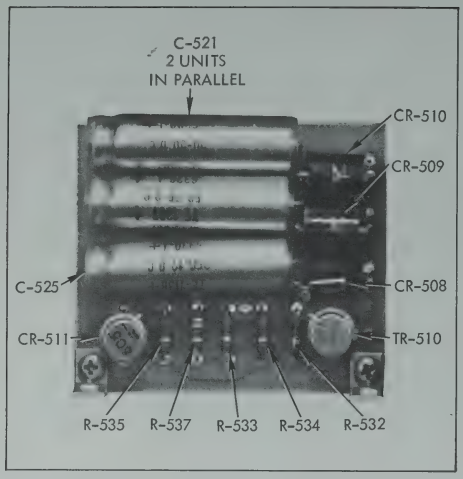


FIGURE 5-14. PRINTED CIRCUIT BOARD (SIDE VIEW)

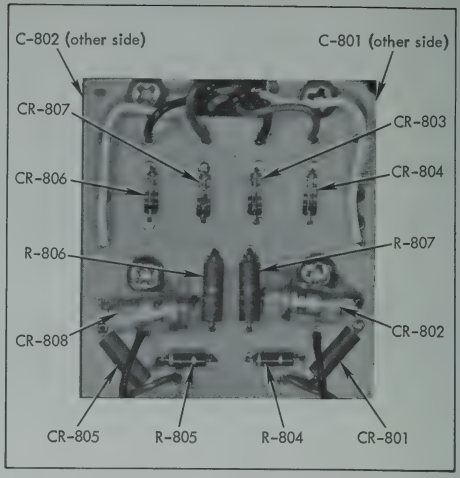


FIGURE 5-15. REFERENCE SUPPLY

5-19. POTENTIOMETER WIPER REPLACEMENT. Rebalance potentiometer wipers are mode of a softer metal than the resistance mandrels and therefore require replacement long before the mandrels. New wiper assemblies are available from the factory.

a. Y-AXIS WIPERS. These assemblies are mounted on the Y_1 and Y_2 pen carriages. New wiper assemblies are Part No. B6335.

(1) Remove the pen from the pen mounting block.

(2) Remove the upper trim strip, mounted by two machine screws.

(3) Remove the Y_2 carriage beam (see paragraph 5-26a).

(4) Remove the Y_1 carriage beam (see paragraph 5-26b).

(5) From the pen tip side, loosen the two screws mounting the eccentric rollers.

(6) Using a stiff wire, position the two rollers to align with the eccentric holes nearest the carriage beam.

(7) Separate the pen carriage from the carriage beam and remove the nylon cord from around the upper and lower beam pulleys.

CAUTION: Do not remove the nylon cord from the pen carriage as this would require restringing the Y-axis. If this does occur, refer to paragraph 5-31 for restringing instructions.

(8) Remove the old wipers by drilling out the mounting rivets taking care not to enlarge the mounting holes.

(9) Rivet the new wipers to the pen carriages and reassemble.

b. X-AXIS WIPER. This assembly is located on the Y slider block at the upper end of the pen carriage beam. New wiper assemblies are Part No. A1937.

(1) Remove the platen, top trim strip, and rear cover.

(2) Tape the X-axis drive cables to pulleys C and J (figure 5-17) to prevent loss of cabling during succeeding steps.

(3) Using an Allen wrench, loosen the set screw fastening the Y-slider bar in place. This screw is located just above Idler Pulley J.

(4) Move the Y-slider bar out the right side of the recorder sufficiently to allow removal of the X-axis wiper.

(5) Install the new wiper, leaving mounting screws slightly loose.

(6) Re-install the slider bar, carefully positioning the rollers on the track at the lower end of the carriage beam. Tighten set screw. The retaining tape may now be removed from the cabling.

(7) Position the wiper assembly so that one wiper contacts the resistance wire mandrel and the other the solid return wire. Move slider bar assembly so that wiper mount aligns with access hole in rear frame. Insert a thin shaft Phillips screwdriver through this hole to tighten mounting screws.

(8) Re-install the platen, trip strip, and cover.

5-20. MECHANICAL MAINTENANCE

5-21. DISASSEMBLY. Access to the various components of the recorder is attained as follows:

a. Remove the AC power cord.

b. For access to the servo amplifier, power supply chassis, X and Y servo motors, and reference supplies, remove four machine screws which fasten the back cover on the instrument. To remove a plug-in chassis, take out four machine screws and pull the unit directly upward from the frame. When replacing a chassis, be sure to align the connector plugs with the corresponding receptacles before fastening.

c. Although removing both amplifier chasses will afford some access to the mechanical drive mechanism, it may be reached more easily by removing the recording platen. Place the carriage as far right as possible, remove platen mounting screws, and slide platen off to the left. The vacuum connection and curve follower contact are separated automatically when the platen is removed. When replacing, tighten the mounting screws securely to reseat these connections.

d. Access to the function and range switches is obtained by removing the cover from the bottom of the control box.

5-22. PEN MAINTENANCE. Pen assemblies should be cleaned thoroughly every two to four weeks by soaking in alcohol or hot water. Clogging during operation may be cleared by one or a combination of the following steps:

a. Apply air pressure through ink filler hole with syringe.

b. Internally clean tip by inserting the stiff fine wire supplied in the accessory kit.

c. Soak pen assembly in alcohol or hot water.

5-23. ADJUSTMENT OF PEN MOUNT. Both pen mounts are held on the carriage beam by eccentrically mounted rollers. To adjust, loosen screws on the pen tip side of the mounts and adjust eccentrics with a stiff wire. Retighten screws.

5-24. ADJUSTMENT OF PEN CARRIAGE BEAM. If a vertical pen trace deviates from perpendicular when compared with correctly aligned paper grids, the carriage beam should be adjusted. Open the control box and loosen the two machine screws at the lower end of the beam. Manually move the beam in the indicated direction until parallel with paper grids. Retighten both screws.

5-25. REMOVAL OF PEN CARRIAGE BEAM. It is necessary to dismount the pen carriage beams for cleaning or replacing the Y-axes rebalance potentiometers, or for installing a new nylon drive cord.

a. REMOVAL OF Y_2 CARRIAGE BEAM.

(1) Remove pens from their respective mounting blocks.

(2) Remove top trim strip, fastened by two machine screws.

(3) Remove two machine screws "A" at the lower end of the pen carriage, figure 5-17. Remove the associated cover and scale depression spring "B".

(4) Lift off scale, being careful not to damage the Y_2 pen drop electromagnet which is still connected to the recorder.

(5) Remove machine screw "C" located just below the lower drive gear.

(6) Remove the two machine screws fastening the beam to the lower end of the mounting block.

(7) The Y_2 carriage beam may now be separated from the Y_1 beam but not removed from the recorder because of the balance potentiometer cable connections. Complete removal requires unsoldering of cable connections.

b. REMOVAL OF Y_1 CARRIAGE BEAM.

(1) The Y_2 carriage beam must first be removed (see paragraph a above).

(2) Remove one machine screw from the center of the beam at the lower end, and two machine screws "D" on either side at the top.

(3) The upper end of the beam is now held only by the nylon drive cord tension around the upper drive pulley. Disconnect the cord from the pulley, taking care not to damage potentiometer connections.

(4) Slide the beam upwards, separating it from the lower carriage track, and carefully invert to expose potentiometer for service.

(5) Complete removal of beam requires unsoldering potentiometer connections.

5-26. ADJUSTMENT OF GEAR MESH. Backlash of the servo gear drive system may be adjusted as follows:

a. Y_1 AXIS GEAR ADJUSTMENT.

(1) Remove the recording platen and back cover (see paragraph 5-22c).

(2) Loosen motor mount clamp screws.

(3) Rotate the motor assembly slightly, first in one direction and then in the other, while moving the pen carriage back and forth until motor pinion rotates freely with minimum backlash. Rotation of motor assembly will vary the mesh between motor pinion and clutch gear due to the eccentric mounting shoulder. A slight amount of backlash is desirable for optimum operation.

(4) Tighten motor mounting screws and recheck for optimum backlash.

b. Y_2 AXIS GEAR ADJUSTMENT.

(1) Remove the top trim strip.

(2) Loosen clamps holding motor to assembly and rotate motor until idler gear and clutch gear are disengaged.

(3) Slightly loosen screw on clutch gear and rotate the eccentric mounting to vary the mesh between the gear and the motor drive shaft. A slight amount of backlash is desirable for optimum operation.

(4) Tighten clutch screw and re-engage idler with clutch.

(5) Before tightening motor clamps, rotate the motor slightly in alternate directions while moving the pen bracket. The motor should rotate freely with a slight amount of backlash.

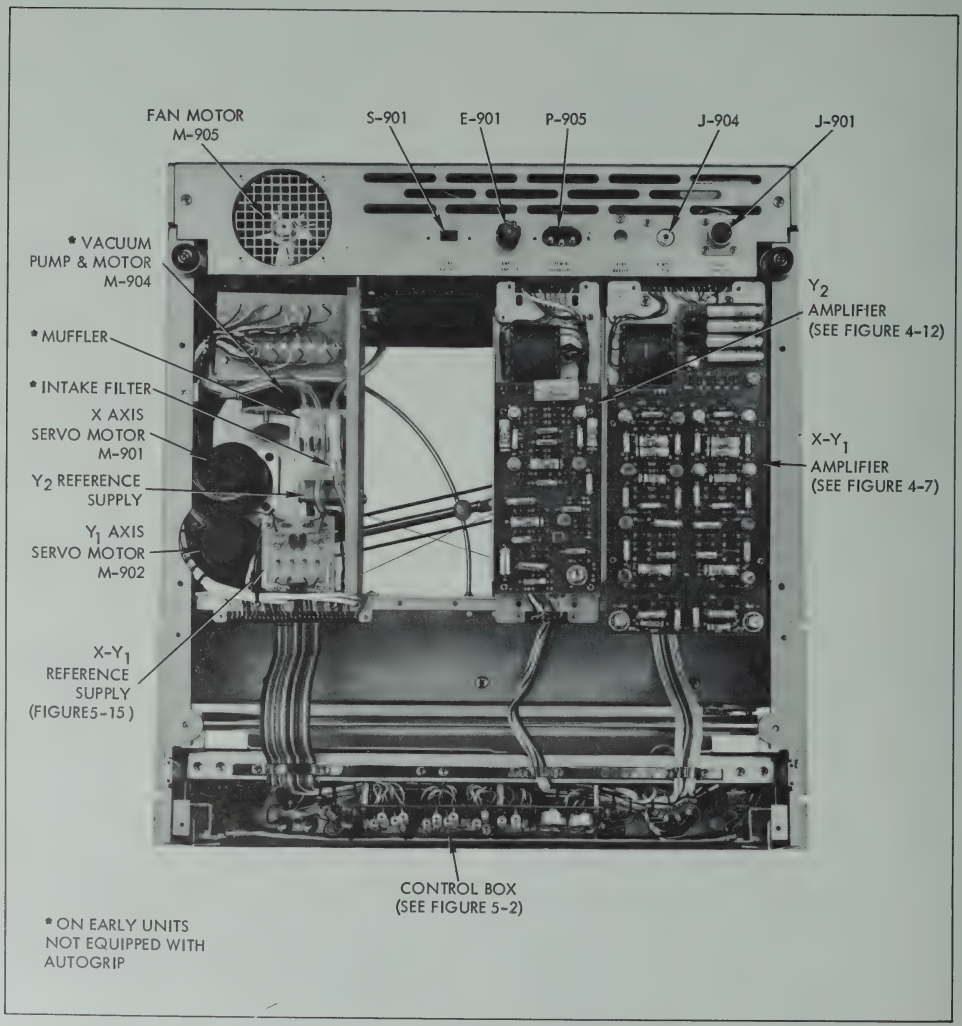


FIGURE 5-16. INSTRUMENT (BOTTOM VIEW)

(6) Tighten motor mounting screws and replace trim strip.

c. X-AXIS GEAR ADJUSTMENT.

(1) Use procedure similar to that for Y_1.

5-27. RESTRINGING INSTRUCTIONS. Restringing the X-axis necessitates removal of the recording platen and lower platen support bar. The Y_1 axis may be restrung by removal of only the platen. The Y_2 axis requires removal of only the upper trim strip.

5-28. MATERIALS REQUIRED. Before attempting to restring the recorder, the following materials should be available.

a. Approximately 8 feet of seven strand stringing cable, 1/64 inch diameter, Part No. 294-0001.

b. 4 Cable Crimps, Part No. 380-0115.

c. 1 Y_1 Nylon Cable Assembly, Part No. A-7856-1.

d. 1 Y_2 Nylon Cable Assembly, Part No. A-7856-6.

e. 2 Drive Belts, Part No. 209-0001-2.

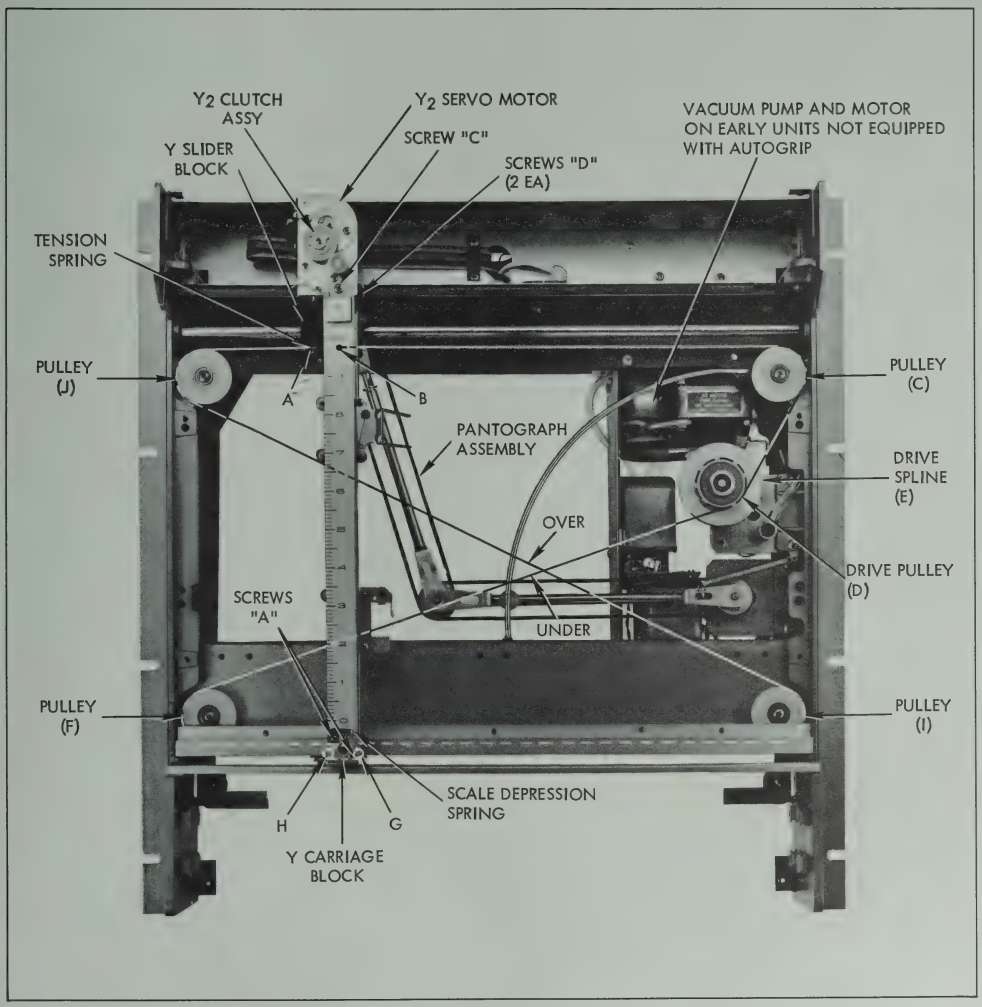


FIGURE 5-17. 2FRA WITHOUT PLATEN (FRONT VIEW)

5-29. X-AXIS RESTRINGING PROCEDURE.

a. Place the carriage assembly at a convenient location, securing with masking tape to prevent movement during subsequent steps.

b. Prepare a small loop approximately 1/4 inch in diameter in one end of a 50 inch length of cable. Clinch with a cable clamp.

c. Attach the prepared loop to the left arm of the tension spring, Point A, figure 5-17, and string cable CW to the right around pulley C to drive pulley D.

d. Wind three turns CW around the drive pulley D, proceeding from the outboard edge toward the inboard.

e. Continue CCW around pulley F to stud G on the bottom of the carriage assembly.

f. Making sure there is no crossover of the cable around pulley D, tighten and fasten at stud G with a cable clamp.

g. Prepare a small loop approximately 1/4 inch in diameter in one end of a second piece of cable 40 inches long and fasten loop with a cable clamp.

h. Attach the prepared loop to the right arm of the tension spring. Point B and string CCW around pulley J. Passing under the first cable, continue CW around idler pulley I to post H on the bottom of the carriage assembly.

i. Attach to stud G, tighten and fasten with a cable clamp.

5-30. Y_1, Y_2 AXES RESTRINGING PROCEDURE.

a. Replacement of the drive belt extending from the upper Y_1 carriage block to the center pulley of the pantograph assembly is self-explanatory.

b. Replacement of the drive belt extending from the Y_1 axis motor to the center pulley of the pantograph is accomplished as follows:

(1) Unhook the drive belt from the center pulley of the pantograph assembly.

(2) Separate the inner and outer halves of the arm connecting the two pulleys by sliding them apart. Do not lose internal spring.

c. Replacement of the nylon cord which drives the Y_1 pen carriage is accomplished as follows:

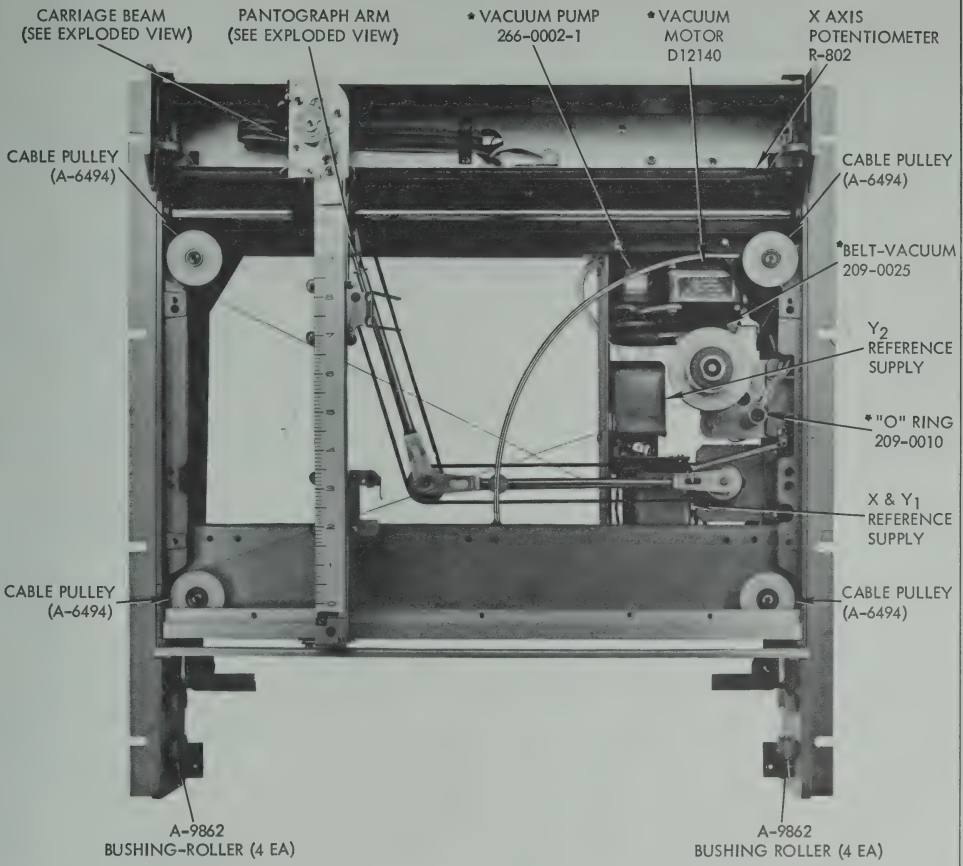
(1) Separate both the Y_2 and Y_1 carriage beams from recorder and from each other (see paragraph 5-25).

(2) Hook free end of tension spring to stud on Y_1 pen carriage. Spring should pull toward Y_1 drive pulley.

(3) Loop cord around the upper pulley and continue around the lower pulley back to the stud. Attach the hooked end of the nylon cord to the pen carriage stud.

(4) Reinstall the Y_1 carriage beam.

d. Replacement of the Y_2 nylon drive cord is accomplished in a manner identical to that for Y_1. When completed, reassemble Y_2 carriage beam.



*(ON MODELS WITHOUT AUTOGRIP)

FIGURE 5-18. 2FRA FRAME

SECTION VI
MODEL 2FR

6-1. DESCRIPTION

6-2. MODEL DIFFERENCES. Prior to Serial No. 79, the 2FRA was designated Model 2FR with several basic differences in specifications. With the exceptions outlined in this section, the 2FR may be installed, operated, and maintained as described for the Model 2FRA in the foregoing sections of this manual.

6-3. SPECIFICATION DIFFERENCES. All specifications for the 2FRA (Section 1-4) apply to the 2FR except the following:

RECORDING PLATEN: Accommodates standard 11" x 17" graph paper with 10" x 15" writing area. Built-in vacuum paper holddown.

DC INPUT RANGES: Ten ranges for each axis: 0.5, 1.0, 5, 10, 50 millivolts/division (inch), and 0.1, 0.5, 1.0, 5, 10 volts/division (inch). Potentiometric operation on most sensitive range by removal of straps on attenuator circuit (provides zero current drain at null).

INPUT RESISTANCE: 200,000 ohms/volt full scale (10") up to 1 volt/div; 2 megohms on all higher ranges.

6-4. OPERATION DIFFERENCES

6-5. INPUT DATA SIGNALS. Input terminals must be supplied with DC signals which are linear functions of the original information. The signals must vary at a rate within the response capabilities of the instrument (10 inches/sec in the X-axis; 20 inches/sec in either Y-axis) and have amplitudes within its scale ranges, 0 to 10 volts/div (inch).

6-6. POTENTIOMETRIC INPUT. For maximum sensitivity with minimum current drain, any axis may be converted to potentiometric input on the most sensitive range by removing straps on the input attenuator circuit (see figure 5-3). In this mode, the source impedance must be 50,000 ohms, or less.

6-7. OPERATING CONTROLS. Model 2FR uses slightly different nomenclature for the control functions:

a. VAC-PWR Switch:

(1) OFF-OFF - All power to instrument is turned off.

(2) OFF-ON - Vacuum system is off; all other parts of instrument are energized.

(3) ON-ON - All power is applied, including vacuum paper grip.

b. PEN-TIME Switch:

(1) STANDBY - Pen is raised off paper; chopper and motor reference phase are turned off.

(2) UP-RESET - All power is applied; pen remains raised for "dry runs". When in TIME mode, pen assumes a "start" position.

(3) DOWN-SWEEP - Pen is lowered to paper and input data will be recorded. When in TIME mode, sweep action is initiated automatically.

c. FUNCTION Switch: Same as Models 2FRA and 2FRAM.

6-8. OPERATION. Taking into consideration the differences outlined in paragraphs 6-1 through 6-7, the Model 2FR operating procedure is the same as described for Model 2FRA, paragraphs 3-13 through 3-24.

6-9. AMPLIFIER DIFFERENCES. The 2FR uses all-transistor amplifiers for each axis. Models 2FRA and 2FRAM have an added nuvistor to each servo amplifier to provide the extra gain required for the 1-megohm input feature.

Switch Range	Input Resistance (ohms/volt)	Full Scale (10") Current Drain (micro-amperes)	Full Scale (10") Input Resistance (ohms)
0.5 mv/div(inch)	200,000	5	1,000
1	200,000	5	2,000
5	200,000	5	10,000
10	200,000	5	20,000
50	200,000	5	100,000
0.1 v/div(inch)	200,000	5	200,000
0.5	200,000	5	1,000,000
1	200,000	5	2,000,000
5	40,000	25	2,000,000
10	20,000	50	2,000,000

FIGURE 6-1. INPUT CHART (2FR)

6-10. (2FR) 1ST & 2ND VOLTAGE AMPLIFIER. Diodes CR-501 and CR-502 provide overload protection for the first two transistors TR-501 and TR-502 which are connected in cascade as conventional voltage amplifiers. A major feedback path is from the emitter of TR-502 to the base of TR-501 through resistor R-504.

6-11. 2FR MAINTENANCE

6-12. VACUUM SYSTEM. The vacuum pump tends to collect dust, dirt, and ink. This may cause reduced efficiency or "freezing". Flushing is recommended at least every 100 hours, as follows:

a. Disconnect intake and exhaust line from pump without removing vacuum assembly.

b. Attach one end of a 10" tygon tube (Moseley Part No. 387-0025) to exhaust side of pump. Using the syringe from accessory kit, half-fill the tubing with Isoprapanol Alcohol (shellac thinner) and connect tube to pump intake. Start pump and circulate alcohol for 10 seconds. Stop pump, disconnect tube, feed into an absorbing cloth, restart pump to discharge alcohol. Repeat this procedure until alcohol remains clean.

c. Check all hose connections, lines, and filter for leakage or obstructions.

d. If all efforts fail to restore normal operation, return to factory for repairs or replacement.

e. Check V-belt of motor drive for wear or cracks.

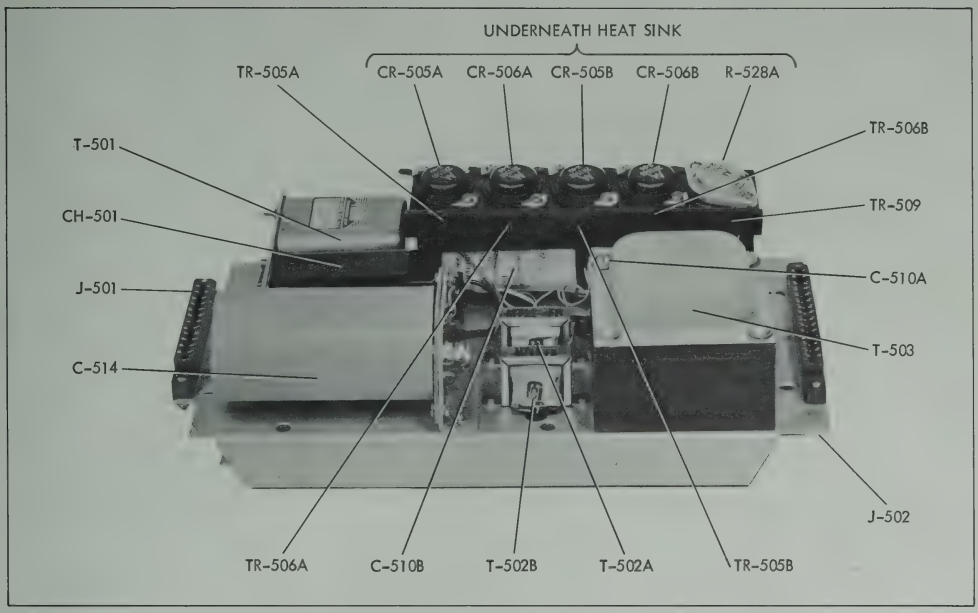


FIGURE 6-2. SERVO AMPLIFIERS AND POWER SUPPLY (TOP VIEW)

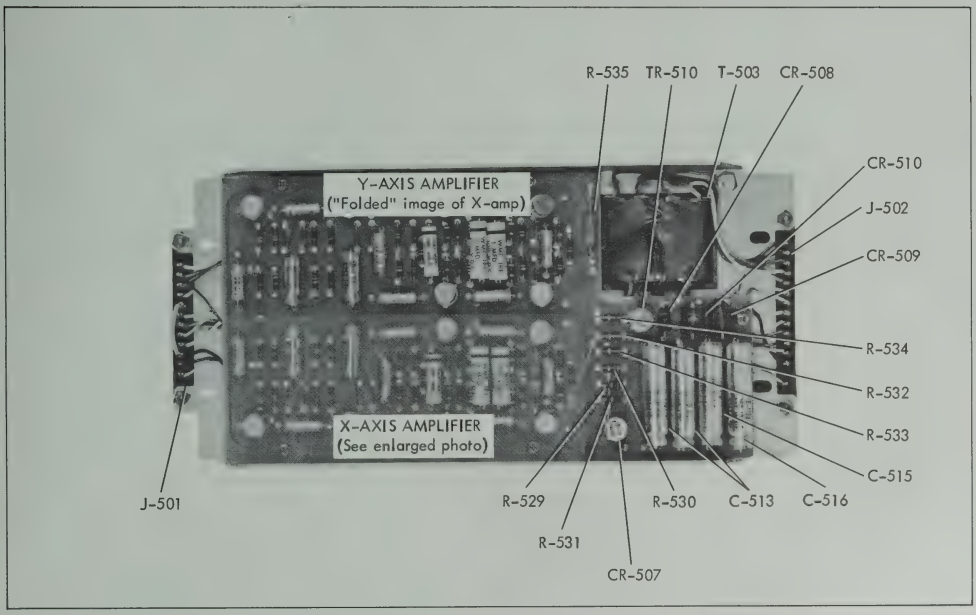


FIGURE 6-3. SERVO AMPLIFIERS AND POWER SUPPLY (BOTTOM VIEW)

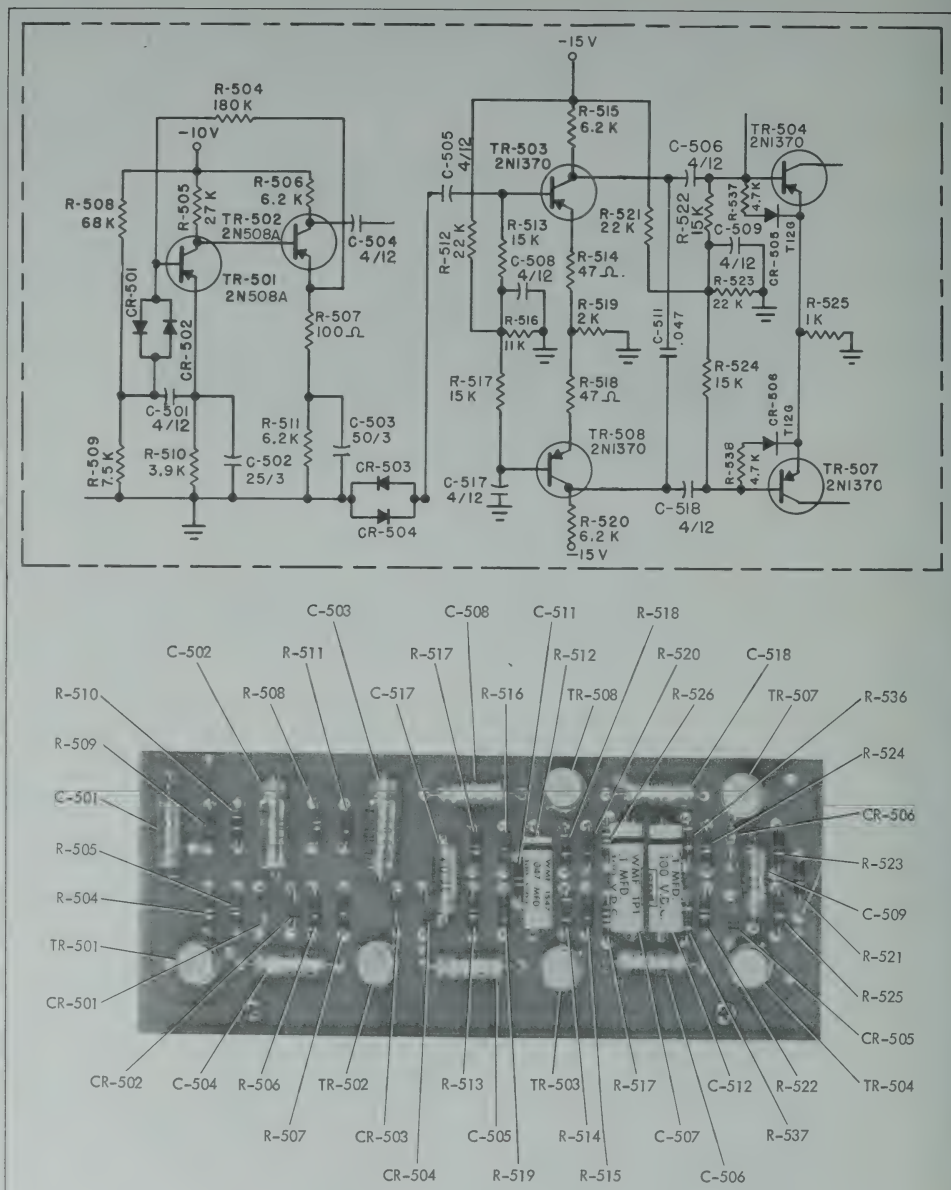


FIGURE 6-4. X-AXIS AMPLIFIER AND SCHEMATIC, ENLARGED VIEW

SECTION VI
MODEL 2FR

6-1. DESCRIPTION

6-2. MODEL DIFFERENCES. Prior to Serial No. 79, the 2FRA was designated Model 2FR with several basic differences in specifications. With the exceptions outlined in this section, the 2FR may be installed, operated, and maintained as described for the Model 2FRA in the foregoing sections of this manual.

6-3. SPECIFICATION DIFFERENCES. All specifications for the 2FRA (Section 1-4) apply to the 2FR except the following:

RECORDING PLATEN: Accommodates standard 11" x 17" graph paper with 10" x 15" writing area. Built-in vacuum paper holddown.

DC INPUT RANGES: Ten ranges for each axis: 0.5, 1.0, 5, 10, 50 millivolts/division (inch), and 0.1, 0.5, 1.0, 5, 10 volts/division (inch). Potentiometric operation on most sensitive range by removal of straps on attenuator circuit (provides zero current drain at null).

INPUT RESISTANCE: 200,000 ohms/volt full scale (10") up to 1 volt/div; 2 megohms on all higher ranges.

6-4. OPERATION DIFFERENCES

6-5. INPUT DATA SIGNALS. Input terminals must be supplied with DC signals which are linear functions of the original information. The signals must vary at a rate within the response capabilities of the instrument (10 inches/sec in the X-axis; 20 inches/sec in either Y-axis) and have amplitudes within its scale ranges, 0 to 10 volts/div (inch).

6-6. POTENTIOMETRIC INPUT. For maximum sensitivity with minimum current drain, any axis may be converted to potentiometric input on the most sensitive range by removing straps on the input attenuator circuit (see figure 5-3). In this mode, the source impedance must be 50,000 ohms, or less.

6-7. OPERATING CONTROLS. Model 2FR uses slightly different nomenclature for the control functions:

a. VAC-PWR Switch:

(1) OFF-OFF - All power to instrument is turned off.

(2) OFF-ON - Vacuum system is off; all other parts of instrument are energized.

(3) ON-ON - All power is applied, including vacuum paper grip.

b. PEN-TIME Switch:

(1) STANDBY - Pen is raised off paper; chopper and motor reference phase are turned off.

(2) UP-RESET - All power is applied; pen remains raised for "dry runs". When in TIME mode, pen assumes a "start" position.

(3) DOWN-SWEEP - Pen is lowered to paper and input data will be recorded. When in TIME mode, sweep action is initiated automatically.

c. FUNCTION Switch: Same as Models 2FRA and 2FRAM.

6-8. OPERATION. Taking into consideration the differences outlined in paragraphs 6-1 through 6-7, the Model 2FR operating procedure is the same as described for Model 2FRA, paragraphs 3-13 through 3-24.

6-9. AMPLIFIER DIFFERENCES. The 2FR uses all-transistor amplifiers for each axis. Models 2FRA and 2FRAM have an added nuvistor to each servo amplifier to provide the extra gain required for the 1-megohm input feature.

Switch Range	Input Resistance (ohms/volt)	Full Scale (10") Current Drain (micro-amperes)	Full Scale (10") Input Resistance (ohms)
0.5 mv/div(inch)	200,000	5	1,000
1	200,000	5	2,000
5	200,000	5	10,000
10	200,000	5	20,000
50	200,000	5	100,000
0.1 v/div(inch)	200,000	5	200,000
0.5	200,000	5	1,000,000
1	200,000	5	2,000,000
5	40,000	25	2,000,000
10	20,000	50	2,000,000

FIGURE 6-1. INPUT CHART (2FR)

6-10. (2FR) 1ST & 2ND VOLTAGE AMPLIFIER. Diodes CR-501 and CR-502 provide overload protection for the first two transistors TR-501 and TR-502 which are connected in cascade as conventional voltage amplifiers. A major feedback path is from the emitter of TR-502 to the base of TR-501 through resistor R-504.

6-11. 2FR MAINTENANCE

6-12. VACUUM SYSTEM. The vacuum pump tends to collect dust, dirt, and ink. This may cause reduced efficiency or "freezing". Flushing is recommended at least every 100 hours, as follows:

a. Disconnect intake and exhaust line from pump without removing vacuum assembly.

b. Attach one end of a 10" tygon tube (Moseley Part No. 387-0025) to exhaust side of pump. Using the syringe from accessory kit, half-fill the tubing with Isoprapanol Alcohol (shellac thinner) and connect tube to pump intake. Start pump and circulate alcohol for 10 seconds. Stop pump, disconnect tube, feed into an absorbing cloth, restart pump to discharge alcohol. Repeat this procedure until alcohol remains clean.

c. Check all hose connections, lines, and filter for leakage or obstructions.

d. If all efforts fail to restore normal operation, return to factory for repairs or replacement.

e. Check V-belt of motor drive for wear or cracks.

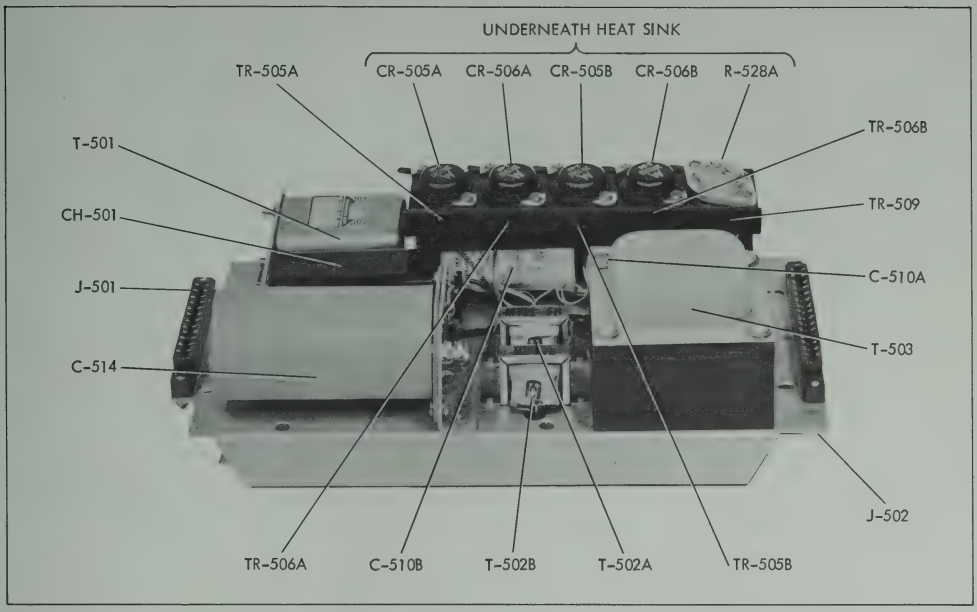


FIGURE 6-2. SERVO AMPLIFIERS AND POWER SUPPLY (TOP VIEW)

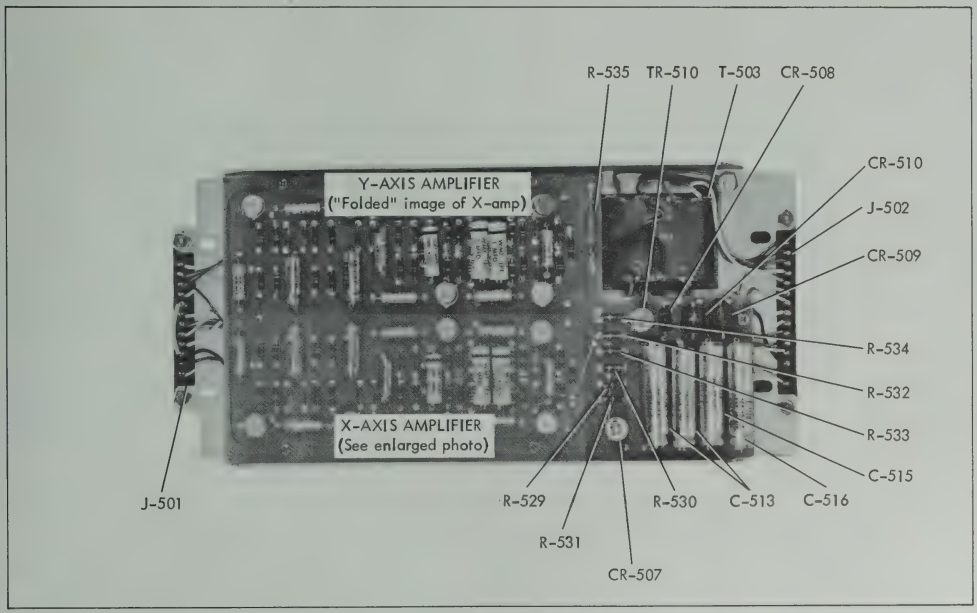


FIGURE 6-3. SERVO AMPLIFIERS AND POWER SUPPLY (BOTTOM VIEW)

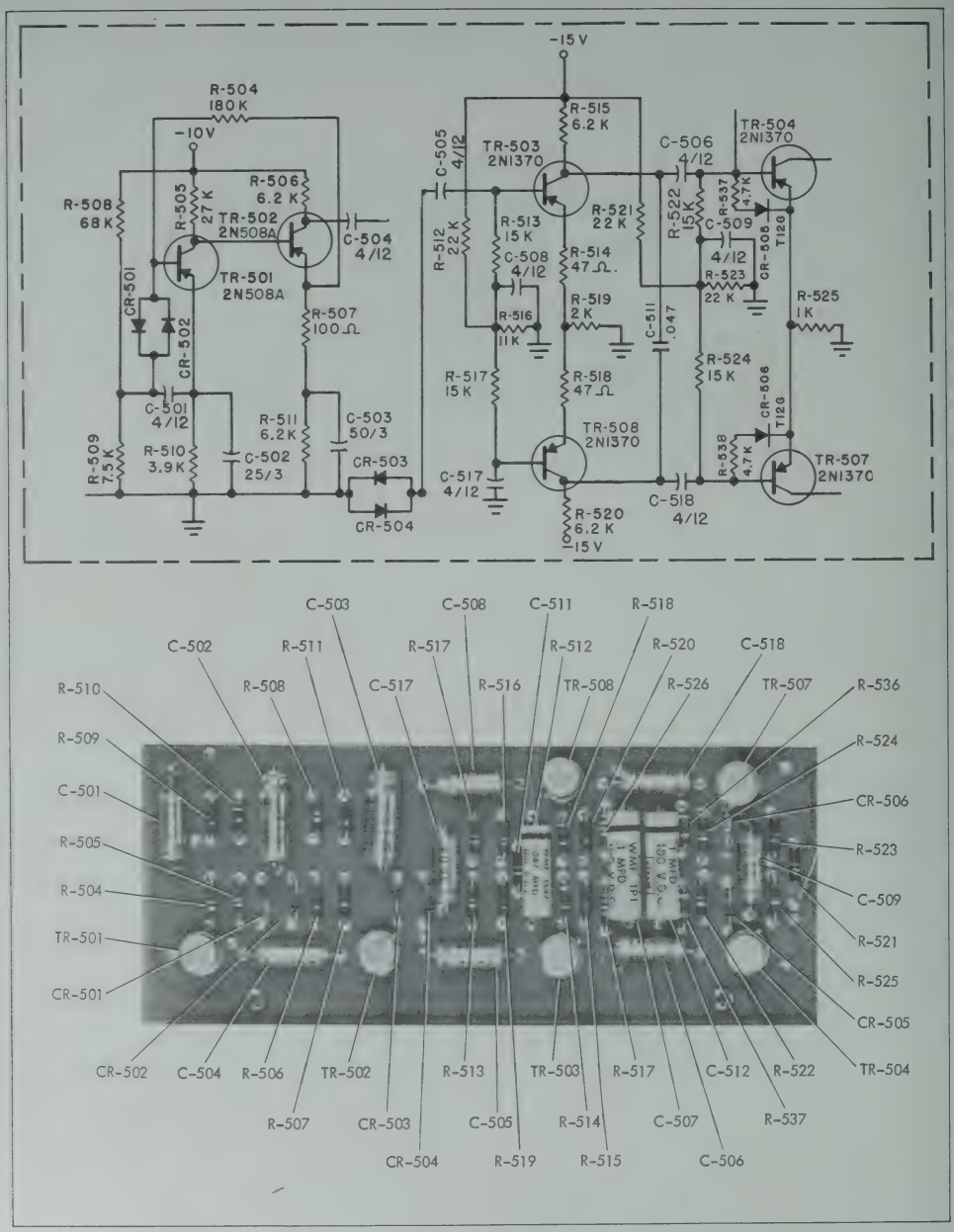
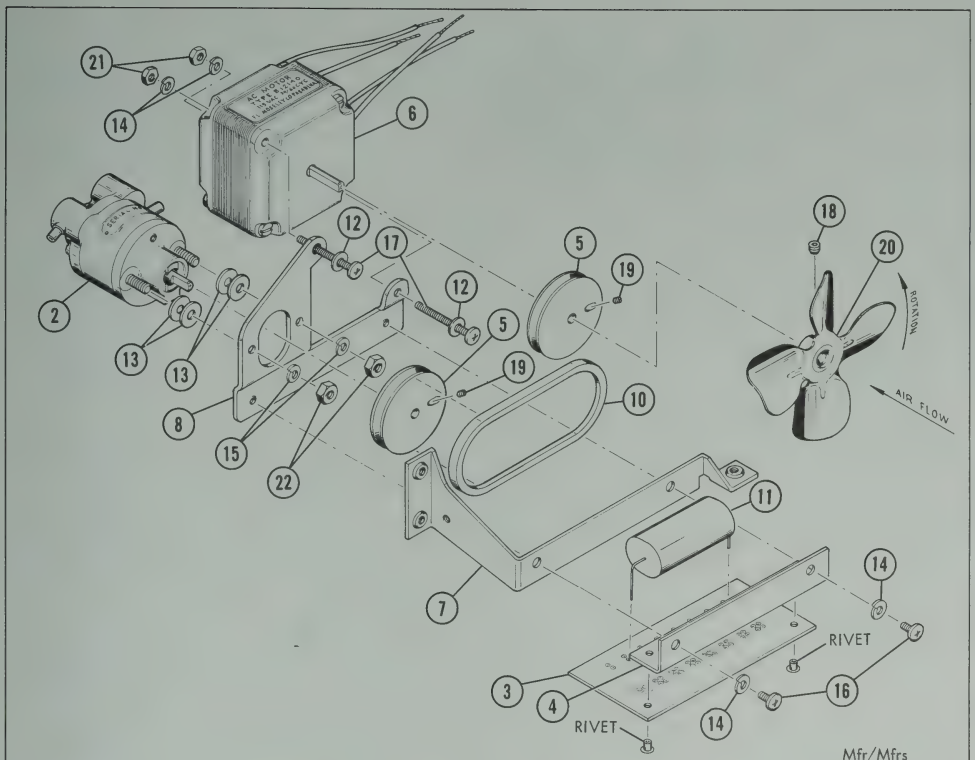


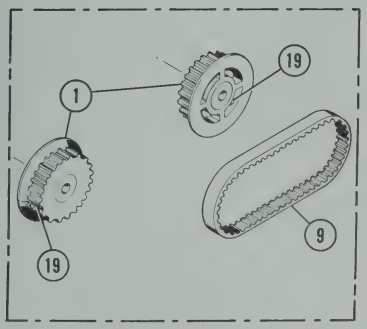
FIGURE 6-4. X-AXIS AMPLIFIER AND SCHEMATIC, ENLARGED VIEW

PARTS LIST FOR AMPLIFIERS AND POWER SUPPLY

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
C-501	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	2
C-502	231-0020	Capacitor, Electrolytic 25 mfd, 3v	Sprague TE1055	
C-503	231-0070	Capacitor, Electrolytic 50 mfd, 3v	Sprague TE1058	
C-504	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	
C-505	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	
C-506	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	
C-507	234-0035	Capacitor, Metalized 0.1 mfd, 100v	C-D WMF IPIE	
C-508	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	
C-509	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	
C-510	231-0107	Capacitor, Electrolytic 30 mfd, 150v	Aerovox E26D585	
C-511	234-0037	Capacitor, Metalized 0.047 mfd, 100v	C-D WMF 1547E	1
C-512	234-0035	Capacitor, Metalized 0.1 mfd, 100v	C-D WMF IPIE	1
C-513	231-0087	Capacitor, Electrolytic 50 mfd, 50v (2 in parallel)	Sprague TE1307	
C-514	231-0067	Capacitor, Electrolytic 1500 mfd, 50v	Mallory WP068	
C-515	231-0096	Capacitor, Electrolytic 250 mfd, 12v	Sprague TE1138	
C-516	231-0096	Capacitor, Electrolytic 250 mfd, 12v	Sprague TE1138	
C-517	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	
C-518	231-0080	Capacitor, Electrolytic 4 mfd, 12v	Sprague TE1123	
CH-501	221-0007	Chopper	Stevens-Arnold BA-11-11	
CR-501	250-0031	Diode	Transitron	3
CR-502	250-0031	Diode	Transitron	
CR-503	250-0031	Diode	Transitron	
CR-504	250-0031	Diode	Transitron	
CR-505	252-0021	Diode	Transitron T-12G	1
CR-506	252-0021	Diode	Transitron T-12G	
CR-507	252-0025	Diode	Diodes Inc., DI-54	1
CR-508	252-0025	Diode	Diodes Inc., DI-54	
CR-509	250-0015	Diode, Zener	HP G31G12H	1
CR-510	252-0036	Diode	Solitron HC-30	1
CR-511	254-0008	Diode	Solitron SD-2	1
CR-512	254-0008	Diode	Solitron SD-2	
R-553	241-0234	Resistor, Composition 820 ohms, 2 W	Allen-Bradley	
R-537	241-0194	Resistor, Composition 4.7 K, 1/4 W, 10%	Allen-Bradley	1
T-501	204-0035	Transformer, Input	Triad G95038	1
T-502	204-0029	Transformer, Interstage	Triad 95005	1
T-503	202-0052	Transformer, Power	Triad 68944	1
TR-501	256-0055	Transistor	Texas Instr. 2N508A	1
TR-502	256-0055	Transistor	Texas Instr. 2N508A	
TR-503	256-0022	Transistor	Texas Instr. 2N1370	2
TR-504	256-0022	Transistor	Texas Instr. 2N1370	
TR-505	256-0053	Transistor	Delco 256-0053	2
TR-506	256-0053	Transistor	Delco 256-0053	
TR-507	256-0022	Transistor	Texas Instr. 2N1370	
TR-508	256-0022	Transistor	Texas Instr. 2N1370	
TR-509	256-0053	Transistor	Delco 256-0053	
TR-510	256-0022	Transistor	Texas Instr. 2N1370	
J501	316-0053	Connector	Amphenol 143-012-01	
J-502	316-0044	Connector	Amphenol 143-015-01	
R-504	241-0147	Resistor, Composition 180 K, 1/4 W, 5%	Allen-Bradley	
R-505	241-0221	Resistor, Composition 27 K, 1/4 W, 10%	Allen-Bradley	
R-506	241-0229	Resistor, Composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-507	241-0137	Resistor, Composition 100 K, 1/4 W, 10%	Allen-Bradley	
R-508	241-0235	Resistor, Composition 68 K, 1/4 W, 10%	Allen-Bradley	
R-509	241-0225	Resistor, Composition 7.5 K, 1/4 W, 5%	Allen-Bradley	
R-510A, B	241-0180	Resistor, Composition 3.9 K, 1/4 W, 10%	Allen-Bradley	
R-511A, B	241-0229	Resistor, Composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-5A, B	241-0149	Resistor, Composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-513A, B	241-0160	Resistor, Composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-514A, B	241-0136	Resistor, Composition 47 ohm, 1/4 W, 5%	Allen-Bradley	

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
R-515	241-0229	Resistor, Composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-516A, B	241-0227	Resistor, Composition 11 K, 1/4 W, 5%	Allen-Bradley	
R-517A, B	241-0160	Resistor, Composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-518A, B	241-0136	Resistor, Composition 47 ohm, 1/4 W, 10%	Allen-Bradley	
R-519A, B	241-0228	Resistor, Composition 2 K, 1/4 W, 5%	Allen-Bradley	
R-520A, B	241-0229	Resistor, Composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-521A, B	241-0149	Resistor, Composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-522A, B	241-0160	Resistor, Composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-523A, B	241-0149	Resistor, Composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-524A, B	241-0160	Resistor, Composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-525A, B	241-0145	Resistor, Composition 1 K, 1/4 W, 10%	Allen-Bradley	
R-526A, B	241-0181	Resistor, Composition 390 K, 1/4 W, 5%	Allen-Bradley	
R-527A, B	241-0181	Resistor, Composition 390 K, 1/4 W, 5%	Allen-Bradley	
R-528A, B	240-0052	Resistor, Composition 1 ohm, 3 W	Allen-Bradley	
R-529	241-0148	Resistor, Composition 3.3 K, 1/4 W, 10%	Allen-Bradley	
R-530	241-0148	Resistor, Composition 3.3 K, 1/4 W, 10%	Allen-Bradley	
R-531	241-0224	Resistor, Composition 8.2 K, 1/4 W, 10%	Allen-Bradley	
R-532	241-0218	Resistor, Composition 1.5 K, 1/4 W, 10%	Allen-Bradley	
R-533	241-0230	Resistor, Composition 82 ohms, 1/4 W, 10%	Allen-Bradley	





B/N	Part No.	Description	Mfr/Mfrs Designation	RS
1	A-8666-2	Pulley, Vacuum Pump		
2	A-10621	Vacuum Pump	Moseley	
3	A-13292	PC Board	Moseley	
4	A-13293	Bracket, PC Board	Moseley	
5	A-13670	Pulley, V-Belt		
6	B-12140	Motor	Moseley	
7	C-9308	Bracket	Moseley	
8	C-12366	Plate-Mounting	Moseley	
9	209-0016	Belt-Timing		1
10	209-0025	V-Belt		
11	234-0053	Capacitor, 1.5/400		
12	360-0032	Washer, Flat, #8		
13	360-0033	Washer, Flat, #10		
14	360-0062	Washer, Lock, #8		
15	360-0063	Washer, Lock, #10		
16	366-1002	Screw, PHM, #8-32 x 5/16		
17	366-1015	Screw, PHM, #8-32 x 1-3/8		
18	375-0030	Screw, Set, #10-32 x 3/16	Bristol	
19	375-0031	Screw, Set, #8-32 x 3/16	Bristol	
20	380-0156	Fan Blade		
21	383-0008	Nut, Hex, #8-32		
22	383-0011	Nut, Hex, #10-32		

FIGURE 6-5. VACUUM PUMP (EXPLODED VIEW)

WAVEFORM NOTES

The waveforms on the schematics were taken with a Hewlett-Packard Model 130C oscilloscope, of a 2FR recorder of known quality. Test points may be made accessible by removing the platen.

To obtain error signal for TP-1, TP-2, TP-3, TP-4, TP-5, TP-7 and TP-8.

a. Manually move pen 1/2 of one sub division (1/20", 1.27 mm).

b. Note error signal on scope.

c. Using zero control suppress zero (set zero beyond graph limits) for same amplitude signal. This allows a constant error signal without manually holding pen off null.

TEST POINTS

TP-1 Photo (a) is taken at null; (b) is at 0.5% full scale off null.

TP-2 Same as TP-1.

TP-3 Same as TP-1.

TP-4 Same as TP-1.

TP-5 Same as TP-1.

TP-6 Servo at null.

TP-7 Same as TP-1.

TP-8 Same as TP-1.

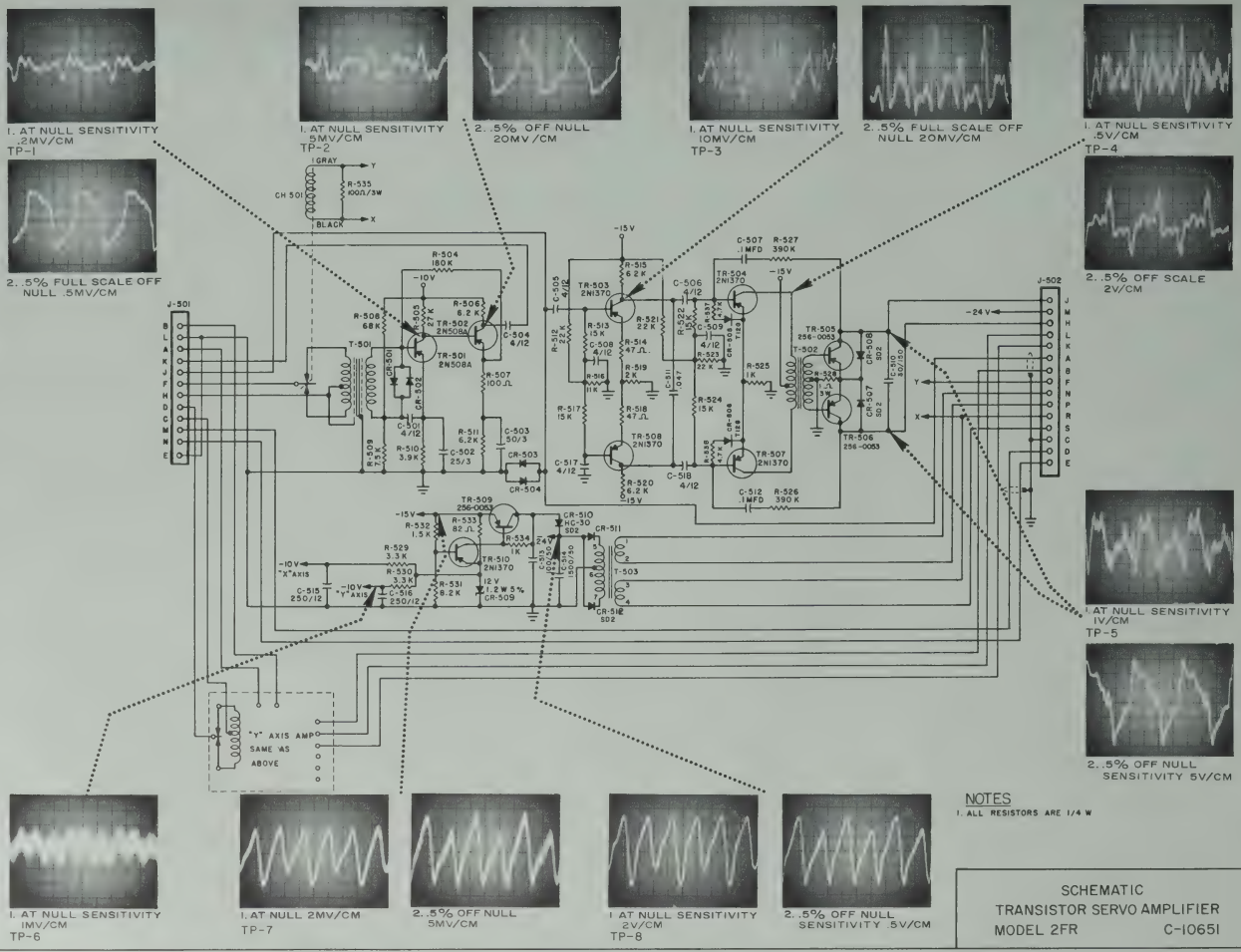
TP-9 Make measurements (with servo at null) across diode, i.e.; the (+) probe is connected to one side of the diode, the (-) probe to the other.

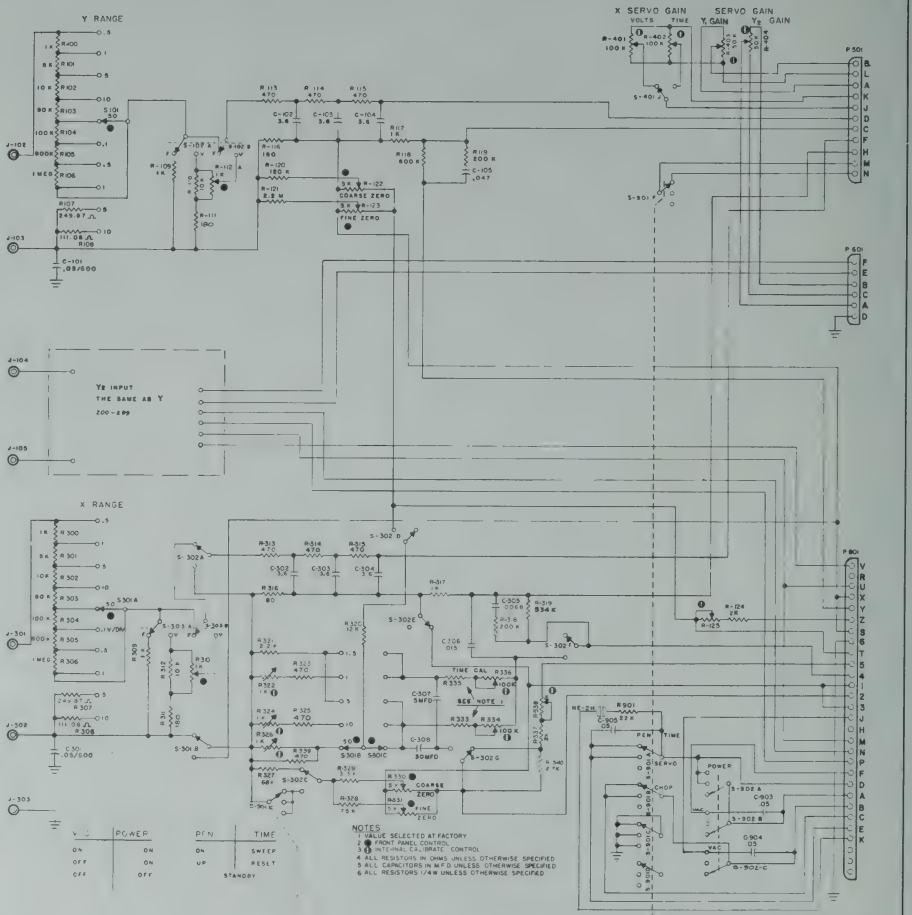
OSCILLOSCOPE SETTINGS

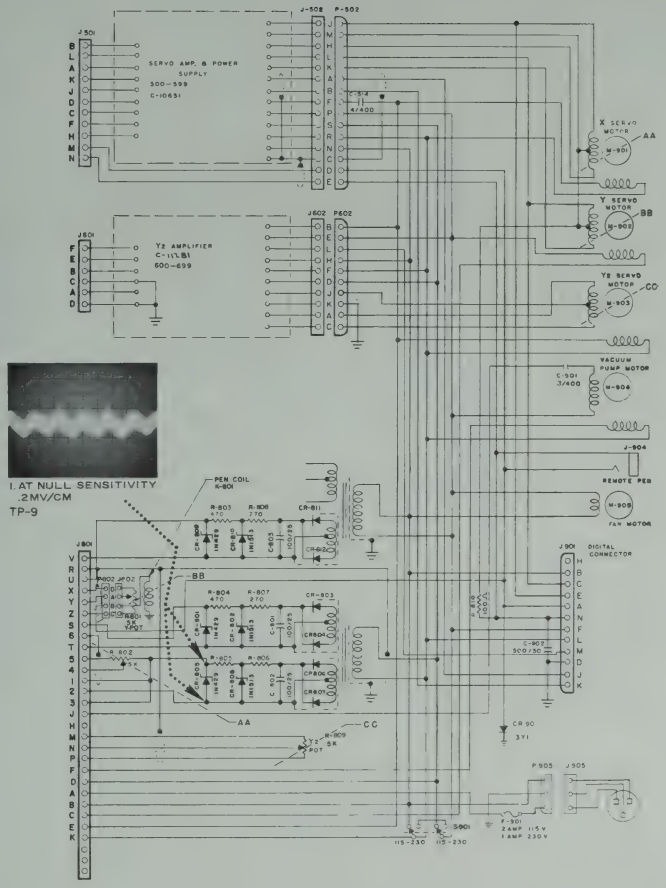
1. 5 ms/cm sweep speed.
2. Attenuator probe NOT used.
3. Observe scope polarity, negative side is connected to chassis ground.
4. All measurements except those taken at TP-9 are referenced to ground.

RECORDER SETTINGS

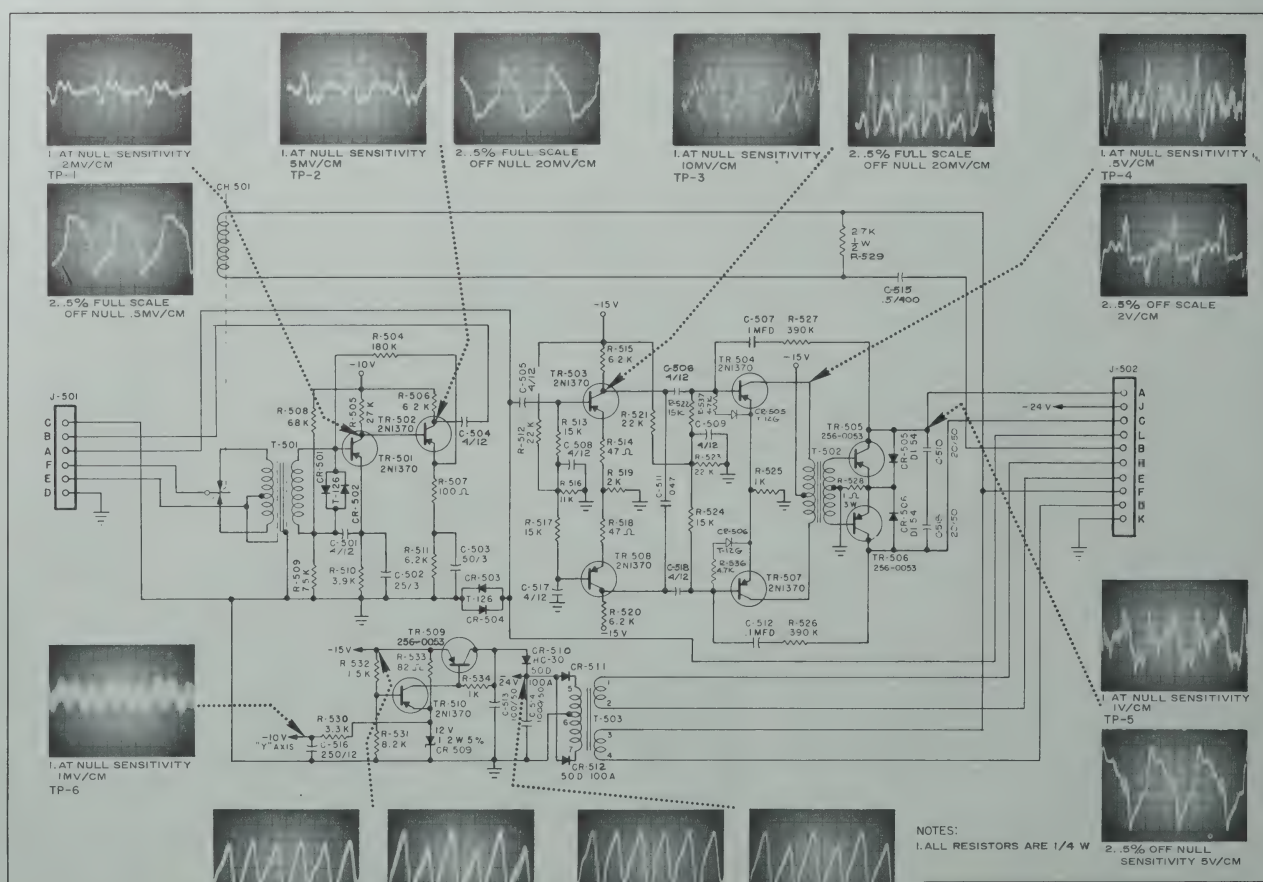
1. Recorder must be grounded.
2. Short input terminals.
3. Recorder must be in normal operating position, i.e., flat on table or horizontal in rack. Do not set on side as the weight of the carriage beam will cause an error signal.
4. Set the gain to 70% (mechanical) of its adjustable range.


1. AT NULL SENSITIVITY .2MV/CM TP-1
1. AT NULL SENSITIVITY .5MV/CM TP-2
2..5% OFF NULL 20MV/CM
1. AT NULL SENSITIVITY 10MV/CM TP-3
2..5% FULL SCALE OFF NULL 20MV/CM
1. AT NULL SENSITIVITY .5V/CM TP-4
2..5% FULL SCALE OFF NULL .5MV/CM
2..5% OFF SCALE 2V/CM
1. AT NULL SENSITIVITY 1V/CM TP-5
2..5% OFF NULL SENSITIVITY 5V/CM
1. AT NULL SENSITIVITY 1MV/CM TP-6
1. AT NULL 2MV/CM TP-7
2..5% OFF NULL 5MV/CM
1. AT NULL SENSITIVITY 2V/CM TP-8
2..5% OFF NULL SENSITIVITY .5V/CM
J-501
J-502
TR-501 2N508A
TR-502 2N508A
TR-503 2N1370
TR-504 2N1370
TR-505 256-0053
TR-506 256-0053
TR-507 2N1370
TR-508 2N1370
TR-509 256-0053
TR-510 2N1370
T-501
T-502
T-503
CR-501
CR-502
CR-503
CR-504
CR-505
CR-506
CR-507
CR-508
CR-509
CR-510 HG-30 SD2
CR-511
CR-512 SD2
"Y" AXIS AMP SAME AS ABOVE
-10V "X" AXIS
-10V "Y" AXIS
-15V
-24V
NOTES
1. ALL RESISTORS ARE 1/4 W
SCHEMATIC
TRANSISTOR SERVO AMPLIFIER
MODEL 2FR C-10651


Y RANGE
X SERVO GAIN
VOLTS
TIME
SERVO GAIN
Y GAIN
Yz GAIN
P 501
BLANK
J
D
C
T
H
M
N
P 501
F
E
B
G
A
D
Yz INPUT
THE SAME AS Y
200-289
X RANGE
P 801
V
R
K
Y
Z
S
6
T
5
4
2
3
C
H
M
N
P
F
D
A
B
C
E
K
POWER
PEN
TIME
ON
OFF
SWEEP
RESET
STANDBY
NOTES
1 VALUE SELECTED AT FACTORY
2 FRONT PANEL CONTROL
3 INTERNAL CALIBRATE CONTROL
4 ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
5 ALL CAPACITORS IN M F D UNLESS OTHERWISE SPECIFIED
6 ALL RESISTORS 1/4 W UNLESS OTHERWISE SPECIFIED



SCHEMATIC
2FR
D-11414


1. AT NULL SENSITIVITY .2MV/CM TP-1
1. AT NULL SENSITIVITY 5MV/CM TP-2
2. .5% FULL SCALE OFF NULL 20MV/CM
1. AT NULL SENSITIVITY 10MV/CM TP-3
2. .5% FULL SCALE OFF NULL 20MV/CM
1. AT NULL SENSITIVITY .5V/CM TP-4
2. .5% FULL SCALE OFF NULL .5MV/CM
2. .5% OFF SCALE 2V/CM
CH 501
2.7K 1/2 W R-529
C-515 .5/400
-15V
R-504 180K
-10V
C-507 1MFD
R-527 390K
TR-504 2N1370
J-501
J-502
-24 V
R-508 68K
R-505 27K
R-506 6.2K
TR-502 2N1370
C-505 4/12
TR-503 2N1370
C-506 4/12
C-504 4/12
T-501
TR-501 2N1370
CR-501
CR-502
R-507 100Ω
R-509 2K
R-510 3.9K
C-501 4/12
R-511 6.2K
C-502 25/3
C-503 50/3
CR-503
CR-504
T-126
R-512 22K
R-513 15K
C-508 4/12
R-514 47JL
R-515 6.2K
R-516 11K
R-517 15K
R-518 47JL
R-519 2K
C-511 .047
C-517 4/12
R-520 6.2K 15V
C-518 4/12
TR-508 2N1370
R-521 15K
R-522 22K
R-523 22K
C-509 4/12
CR-505
CR-506
T-126
R-525 1K
R-524 15K
R-526 4.7K
TR-507 2N1370
C-512 1MFD
R-526 390K
TR-505 256-0053
TR-506 256-0053
T-502
R-528 1K 3W
CR-504 D154
CR-505 D154
C-510 .054
C-514 .054
25-250
25-250
AT NULL SENSITIVITY 1V/CM TP-5
TR-509 256-0053
-15V
R-532 1.5K
R-533 82JL
R-534 1K
TR-510 2N1370
R-530 3.3K
-10V "Y" AXIS
R-516 250/12
R-531 8.2K
12V 1.2W 5% CR 509
CR-510 HC-30 50D
CR-511
T-503
CR-512 50D 100A
1. AT NULL SENSITIVITY 1MV/CM TP-6
1. AT NULL 2MV/CM TP-7
2. .5% OFF NULL 5MV/CM
1. AT NULL SENSITIVITY .2V/CM TP-8
2. .5% OFF NULL SENSITIVITY .5V/CM
2. .5% OFF NULL SENSITIVITY 5V/CM
NOTES:
1. ALL RESISTORS ARE 1/4 W
SCHEMATIC
TRANSISTOR SERVO AMPLIFIER
MODEL 2FR C-11281

SECTION VII
PARTS LIST

MODEL 2FRA & 2FRAM PARTS LIST

7-1. RECOMMENDED SPARES. This section lists all components on the schematic and items with mortality experience. Recommended spare parts for maintaining the instrument for a one year period are designated in column RS.

7-2. ORDERING: When ordering parts, the instrument TYPE and complete serial number should be included with the description as given in this section. To order a part not listed, describe the item, its location, and function. Orders and inquiries should be placed with your area field office.

PARTS LIST CONTROL BOX AND MECHANICAL ASSEMBLY

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
C-101	234-0049	Capacitor, mylar .05 mfd/600 V	Cornell-Dubilier WMF6S5	1
C-102	234-0039	Capacitor, metallized mylar .015 mfd/200 V	Faradyne MFC153M	1
C-103	234-0037	Capacitor, mylar .047 mfd/100 V	Cornell-Dubilier WMF1S47E	1
C-201	234-0049	Capacitor, mylar .05 mfd/600 V	Cornell-Dubilier WMF6S5	1
C-202	234-0039	Capacitor, metallized mylar .015 mfd/200 V	Faradyne MFC153M	
C-203	234-0037	Capacitor, mylar .047 mfd/100 V	Cornell-Dubilier WMF1S47E	
C-301	234-0049	Capacitor, mylar .05 mfd/600 V	Cornell-Dubilier WMF6S5	
C-302	234-0039	Capacitor, metallized mylar .015 mfd/200 V	Faradyne MFC153M	
C-303	235-0003	Capacitor, tantalum 5 mfd/50 V	Fansteel PP5B50A1	2
C-304	235-0007	Capacitor, tantalum 30 mfd/6 V	Fansteel PP30B6A1	2
C-305	234-0037	Capacitor, metallized mylar .015 mfd/200 V	Faradyne MFC153M	
C-306	233-0043	Capacitor, mylar .05 mfd/400 V	Cornell-Dubilier WMF4S5	
C-514	234-0043	Capacitor, metallized mylar 4 mfd/400 V	Electron Products D4-405	
C-801	231-0066	Capacitor, electrolytic 100 mfd/25 V	Sprague TE-1211	
C-802	231-0066	Capacitor, electrolytic 100 mfd/25 V	Sprague TE-1211	1
C-803	231-0066	Capacitor, electrolytic 100 mfd/25 V	Sprague TE-1211	
C-901	234-0053	Capacitor, metallized mylar 1.5 mfd/400 V	Electrocube 210B1E155K	
C-902	231-0078	Capacitor, electrolytic 500 mfd/50 V	Sprague TVA-1315	
C-903	231-0078	Capacitor, electrolytic 500 mfd/50 V (if installed)	Sprague TVA-1315	1
CR-101	252-0028	Diode, zener	1N821	1
CR-201	252-0028	Diode, zener	1N821	1
CR-301	252-0028	Diode, zener	1N821	1
CR-801	252-0028	Diode, zener	Hoffman 1N429	2
CR-802	252-0017	Diode, zener	International-Rec. 1N1513	2
CR-803	252-0021	Diode	Transitron T12G	2
CR-804	252-0021	Diode	Transitron T12G	
CR-805	252-0028	Diode, zener	Hoffman 1N429	

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
CR-806	252-0021	Diode	Transitron T12G	
CR-807	252-0021	Diode	Transitron T12G	
CR-808	252-0017	Diode, zener	International-Rec. 1N1513	
CR-809	252-0028	Diode, zener	Hoffman 1N429	
CR-810	252-0017	Diode, zener	International-Rec. 1N1513	
CR-811	252-0021	Diode	Transitron T12G	
CR-812	252-0021	Diode	Transitron T12G	
CR-901	254-0001	Diode	International-Rec. 3Y1	1
CR-902	254-0001	Diode, Event Marker (if installed)	International-Rec. 3Y1	
F-901	331-0053	Fuse, 2 A, 230 V	Bussman 3PG	10
	331-0003	Fuse, 3 A, 115 V		
J-101	312-0024	Binding post - red	HP G10E	
J-102	312-0025	Binding post - black	HP G10F	
J-201	312-0024	Binding post - red	HP G10E	
J-202	312-0025	Binding post - black	HP G10F	
J-301	312-0024	Binding post - red	HP G10E	
J-302	312-0025	Binding post - black	HP G10F	
J-801	319-0034	Connector - Printed Circuit	Space Products EZ1-28-D	1
J-901	316-0038	Connector - Digital	Amphenol 165-12	
J-903		Connector, Event Marker (if installed)		
J-904	346-0026	Jack, phone - Remote pen	Switchcraft 41	1
J-905	296-0007	Cord, power - removable	Belden PH-151	1
			CS9941-PH-104 7.5	
K-801	A-6714	Electromagnet, pen coil	Moseley	2
M-901	A-10475	Motor, servo	Moseley	1
M-902	A-10475	Motor, servo	Moseley	
M-903	227-0022	Motor, servo	Daystrom Type 15	1
M-904	D-12140	Motor, vacuum	Moseley	2
M-905	226-0018	Motor, fan	Barber-Colman YAA 707-3	1
P-501	A-9247	Connector - Printed Circuit	Moseley	
P-502	A-10571	Connector - Printed Circuit	Moseley	
P-601	A-9247	Connector - Printed Circuit	Moseley	
P-602	A-10571	Connector - Printed Circuit	Moseley	
P-801	A-9246	Connector - Printed Circuit	Moseley	
P-905	319-0032	Receptacle, power	Tower H-1061JG	
PL-901	336-0035	Pilot light, NE-2H	Sloan 859-1A-6	2
R-101	243-0410	Resistor, precision ww 990 K, 0.1%	Cinema 410E	1
R-102	243-0411	Resistor, precision ww 9.9 K, 0.1%	Cinema 410E	1
R-103	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-104	243-0029	Resistor, precision ww 100 ohm, 0.1%	Cinema 410E	
R-105	236-0096	Resistor, variable 100 K	CTS 35820	
R-106	241-0194	Resistor, composition 4.7, 1/4 W, 10%	Allen-Bradley	
R-107	243-0148	Resistor, precision ww 500 ohm, 0.1%	Cinema 410E	
R-108	243-0148	Resistor, precision ww 500 ohm, 0.1%	Cinema 410E	
R-109	243-0088	Resistor, precision ww 4 K, 0.1%	Cinema 410E	
R-110	243-0075	Resistor, precision ww 5 K, 0.1%	Cinema 410E	
R-111	243-0427	Resistor, precision ww 500 ohm, 1%	Cinema 410E	
R-112	241-0239	Resistor, composition 220 K, 1/4 W, 10%	Allen-Bradley	
R-113	241-0276	Resistor, composition 620 K, 1/4 W, 5%	Allen-Bradley	
R-114	243-0334	Resistor, precision ww 390.6 K, 1%	Cinema 410E	
R-115	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-117	236-0053	Resistor, variable 2.5 K	Clarostat A-43-2500	
R-118	243-0412	Resistor, precision ww 1500 ohm, 1%	Cinema 410E	
R-119	236-0059	Resistor, variable 1 K	CTS BK12449	
R-120	243-0327	Resistor, precision ww 2 K, 1%	Cinema 410E	
R-121	243-0179	Resistor, precision ww 1 K, 1%	Cinema 410E	
R-122	241-0157	Resistor, composition 47 K, 1/4 W, 10%	Allen-Bradley	
R-123	241-0210	Resistor, composition 100 K, 1/4 W, 10%	Allen-Bradley	
R-124	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-125	236-0029	Resistor, variable 50 K	CTS 33883	1
R-201	243-0410	Resistor, precision ww 990 K, 0.1%	Cinema 410E	
R-202	243-0411	Resistor, precision ww 9.9 K, 0.1%	Cinema 410E	
R-203	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-204	243-0029	Resistor, precision ww 100 ohm, 0.1%	Cinema 410E	

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
R-205	236-0096	Resistor, variable 100 K	CTS 35820	1
R-206	241-0194	Resistor, composition 4.7 K, 1/4 W, 10%	Allen-Bradley	
R-207	243-0148	Resistor, precision ww 500 ohm, 0.1%	Cinema 410E	
R-208	243-0148	Resistor, precision ww 500 ohm, 0.1%	Cinema 410E	
R-209	243-0088	Resistor, precision ww 4 K, 0.1%	Cinema 410E	
R-210	243-0075	Resistor, precision ww 5 K, 0.1%	Cinema 410E	
R-211	243-0427	Resistor, precision ww 500 ohm, 1%	Cinema 410E	
R-212	241-0239	Resistor, composition 220 K, 1/4 W, 10%	Allen-Bradley	
R-213	241-0276	Resistor, composition 620 K, 1/4 W, 5%	Allen-Bradley	
R-214	243-0334	Resistor, precision 390.6 K, 1%	Cinema 410E	
R-215	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-217	236-0053	Resistor, variable 2.5 K	Clarostat A-43-2500	1
R-218	243-0412	Resistor, precision ww 1500 ohm, 1%	Cinema 410E	
R-219	236-0059	Resistor, variable 1 K	CTS BK12449	1
R-220	243-0327	Resistor, precision ww 2 K, 1%	Cinema 410E	
R-221	243-0179	Resistor, precision ww 1 K, 1%	Cinema 410E	
R-222	241-0157	Resistor, composition 47 K, 1/4 W, 10%	Allen-Bradley	
R-223	241-0210	Resistor, composition 100 K, 1/4 W, 10%	Allen-Bradley	
R-224	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-225	236-0029	Resistor, variable 50 K	CTS 33883	
R-301	243-0410	Resistor, precision ww 990 K, 0.1%	Cinema 410E	
R-302	243-0411	Resistor, precision ww 9.9 K, 0.1%	Cinema 410E	
R-303	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-304	243-0029	Resistor, precision ww 100 ohm, 0.1%	Cinema 410E	
R-305	236-0096	Resistor, variable 100 K	CTS 35820	
R-306	241-0194	Resistor, composition 4.7 K, 1/4 W, 10%	Allen-Bradley	
R-307	243-0148	Resistor, precision ww 500 ohm, 0.1%	Cinema 410E	
R-308	243-0427	Resistor, precision ww 500 ohm, 1%	Cinema 410E	
R-309	243-0088	Resistor, precision ww 4 K, 0.1%	Cinema 410E	
R-310	243-0075	Resistor, precision ww 5 K, 0.1%	Cinema 410E	
R-311	242-0121	Resistor, precision, carbon 26.7 K, 1/2 W, 1%	Aerovox OPSX 1/2	
R-312	241-0216	Resistor, composition 680 ohms, 1/4 W, 10%	Allen-Bradley	
R-313	236-0059	Resistor, variable 1 K	CTS BK12449	2
R-314	241-0177	Resistor, composition 2.2 K, 1/4 W, 10%	Allen-Bradley	
R-315	241-0216	Resistor, composition 680 ohms, 1/4 W, 10%	Allen-Bradley	
R-316	236-0059	Resistor, variable 1 K	CTS BK12449	
R-317	236-0070	Resistor, variable 500 ohm	CTS BR12448	1
R-318		Resistor (Value selected at factory)		
R-319		Resistor (Value selected at factory)		
R-320	236-0095	Resistor, variable 100 K	CTS 35820	
R-321	236-0095	Resistor, variable 100 K	CTS 35820	
R-322	241-0312	Resistor, composition 130 K, 1/4 W, 5%	Allen-Bradley	
R-323	241-0148	Resistor, composition 3.3 K, 1/4 W, 10%	Allen-Bradley	
R-324	236-0053	Resistor, variable 2.5 K	Clarostat A-43-2500	
R-325	241-0157	Resistor, composition 47 K, 1/4 W, 10%	Allen-Bradley	
R-327	243-0412	Resistor, precision ww 1500 ohm, 1%	Cinema 410E	
R-328	243-0412	Resistor, precision ww 1500 ohm, 1%	Cinema 410E	
R-329	243-0327	Resistor, precision ww 2 K, 1%	Cinema 410E	
R-330	236-0059	Resistor, variable 1 K	CTS BK12449	
R-331	241-0229	Resistor, composition 6.2 K, 1/4 W, 10%	Allen-Bradley	
R-332	243-0179	Resistor, precision ww 1 K, 1%	Cinema 410E	
R-333	241-0157	Resistor, composition 47 K, 1/4 W, 10%	Allen-Bradley	
R-334	241-0210	Resistor, composition 100 K, 1/4 W, 10%	Allen-Bradley	
R-335	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-336	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-337	243-0473	Resistor, precision ww 240 K, 1%	Cinema 410E	
R-338	243-0406	Resistor, precision ww 300 ohm, 1%	Cinema 410E	
R-339	236-0006	Resistor, variable 100 K	Centralab BAO 11-1133	
R-340	236-0006	Resistor, variable 100 K	Centralab BAO 11-1133	
R-801	A-6712	Resistor, variable 5 K (Y_1 axis balance)	Moseley	2
R-802	A-11451	Resistor, variable 5 K (X axis rebalance)	Moseley	2
R-803	241-0158	Resistor, composition 470 ohm, 1/2 W, 10%	Allen-Bradley	
R-804	241-0158	Resistor, composition 470 ohm, 1/2 W, 10%	Allen-Bradley	

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
R-805	241-0158	Resistor, composition 470 ohm, 1/2 W, 10%	Allen-Bradley	
R-806	241-0096	Resistor, composition 270 ohm, 1/2 W, 5%	Allen-Bradley	
R-807	241-0096	Resistor, composition 270 ohm, 1/2 W, 5%	Allen-Bradley	
R-808	241-0096	Resistor, composition 270 ohm, 1/2 W, 5%	Allen-Bradley	
R-809	A-6712	Resistor, variable 5 K (Y_2 axis balance)	Moseley	2
R-810	240-0020	Resistor, non-precision ww 100 ohm, 3 W	Sprague 242E-1015	1
R-901	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-902	240-0019	Resistor, power 50 ohm, 5 W (if installed)	Ohmite	1
S-101	262-0070	Switch, range, Y_1 axis	CTS	
S-103	261-0031	Switch, slide, fixed-variable	Muter 4603-T	2
S-201	262-0070	Switch, range, Y_2 axis	CTS	
S-203	261-0031	Switch, slide, fixed-variable	Muter 4603-T	
S-301	262-0069	Switch, range, X axis	CTS	1
S-302	262-0071	Switch, function, X axis	CTS	1
S-303	261-0031	Switch, slide, fixed-variable	Muter 4603-T	
S-401	262-0053	Switch, lever, Servo-Sweep	Switchcraft 6S-1931A	2
S-402	261-0035	Switch, toggle, Power-Vacuum	Carling IG282-72 X MOS2	2
S-903	261-0037	Switch, snap, Power Conversion	HP 3101-0033	1
T-801	204-0026	Transformer, reference	Topaz 00837	1
T-802	204-0026	Transformer, reference	Topaz 00837	1

For the Model 2FRAM (metric scaled), the following 18 resistors are substituted for those listed on the preceding pages.

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
R-107	243-0069	Resistor, precision, ww 750 ohm, 0.1%	Cinema 410E	1
R-109	243-0432	Resistor, precision, ww 3.75 K, 0.1%	Cinema 410E	1
R-110	243-0431	Resistor, precision, ww 7.5 K, 0.1%	Cinema 410E	1
R-122	241-0209	Resistor, composition, 33 K, 1/4 W, 10%	Allen-Bradley	
R-123	241-0147	Resistor, composition, 180 K, 1/4 W, 10%	Allen-Bradley	
R-124	241-0178	Resistor, composition, 300 K, 1/4 W, 10%	Allen-Bradley	
R-207	243-0069	Resistor, precision, ww 750 ohm, 0.1%	Cinema 410E	1
R-209	243-0432	Resistor, precision, ww 3.75 K, 0.1%	Cinema 410E	1
R-210	243-0431	Resistor, precision, ww 7.5 K, 0.1%	Cinema 410E	1
R-222	241-0209	Resistor, composition, 33 K, 1/4 W, 10%	Allen-Bradley	
R-223	241-0147	Resistor, composition, 180 K, 1/4 W, 10%	Allen-Bradley	
R-224	241-0178	Resistor, composition, 300 K, 1/4 W, 10%	Allen-Bradley	
R-307	243-0069	Resistor, precision, ww 750 ohm, 0.1%	Cinema 410E	
R-309	243-0432	Resistor, precision, ww 3.75 K, 0.1%	Cinema 410E	
R-310	243-0431	Resistor, precision, ww 7.5 K, 0.1%	Cinema 410E	
R-333	241-0209	Resistor, composition, 33 K, 1/4 W, 10%	Allen-Bradley	
R-334	241-0147	Resistor, composition, 180 K, 1/4 W, 10%	Allen-Bradley	
R-335	241-0178	Resistor, composition, 300 K, 1/4 W, 10%	Allen-Bradley	

PARTS LIST - X AND Y_1 AMPLIFIERS

P/N M-14304
(Refer to Schematic MC-11635)

C-501	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	1
C-502	231-0020	Capacitor, electrolytic 25 mfd/3 V	Sprague TE-1055	1
C-503	231-0020	Capacitor, electrolytic 25 mfd/3 V	Sprague TE-1055	1
C-504	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-505	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-506	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-507	234-0035	Capacitor, mylar .1 mfd/100 V	Cornell-Dubilier WMF1P1E	
C-508	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-509	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-510	231-0107	Capacitor, electrolytic 30 mfd/150 V	Aerovox E26D585	1

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
C-511	234-0037	Capacitor, mylar .047 mfd/100 V	Cornell-Dubilier WMF1S47E	
C-512	234-0035	Capacitor, mylar .1 mfd/100 V	Cornell-Dubilier WMF1P1E	
C-513	231-0087	Capacitor, electrolytic 50 mfd/50 V (2 in parallel)	Sprague TE-1307	1
C-514	231-0067	Capacitor, electrolytic 1500 mfd/50 V	Mallory WP068	1
C-515	231-0096	Capacitor, electrolytic 250 mfd/12 V	Sprague TE-1138	
C-516	231-0096	Capacitor, electrolytic 250 mfd/12 V	Sprague TE-1138	
C-517	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-518	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-519	231-0095	Capacitor, electrolytic 50 mfd/10 V	Sprague TE-1119	
C-520	231-0095	Capacitor, electrolytic 50 mfd/10 V	Sprague TE-1119	
C-521	233-0019	Capacitor, paper .0022 mfd/100 V	C-D Miniroc STM1D22	
C-522	235-0008	Capacitor, tantalum 30 mfd/6 V	Fansteel F115	
CH-501	221-0007	Chopper	Stevens-Arnold BA-11-11	1
CR-501	252-0027	Diode	International-Rec. 1N1594	2
CR-503	252-0021	Diode	Transitron T12G	
CR-504	252-0021	Diode	Transitron T12G	
CR-505	252-0021	Diode	Transitron T12G	
CR-506	252-0021	Diode	Transitron T12G	
CR-507	252-0025	Diode	Diodes, Inc. DI-54	4
CR-508	252-0025	Diode	Diodes, Inc. DI-54	
CR-509	250-0015	Diode, zener	HP #G-31G12H	2
CR-510	252-0036	Diode	Solitron HC30	2
CR-511	252-0038	Diode	Solitron SOD100A	2
CR-512	252-0038	Diode	Solitron SOD100A	
J-501	316-0053	Connector	Amphenol 143-012-01	
J-502	316-0044	Connector	Amphenol 143-015-01	
R-504	241-0157	Resistor, composition 47 K, 1/4 W, 10%	Allen-Bradley	
R-505	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-506	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-507	241-0137	Resistor, composition 100 ohm, 1/4 W, 5%	Allen-Bradley	
R-508	241-0159	Resistor, composition 30 K, 1/4 W, 5%	Allen-Bradley	
R-509	241-0229	Resistor, composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-510	241-0137	Resistor, composition 100 ohm, 1/4 W, 5%	Allen-Bradley	
R-511	241-0224	Resistor, composition 8.2 K, 1/4 W, 10%	Allen-Bradley	
R-512	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-513	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-514	241-0136	Resistor, composition 47 ohm, 1/4 W, 5%	Allen-Bradley	
R-515	241-0229	Resistor, composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-516	241-0227	Resistor, composition 11 K, 1/4 W, 5%	Allen-Bradley	
R-517	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-518	241-0136	Resistor, composition 47 ohm, 1/4 W, 5%	Allen-Bradley	
R-519	241-0228	Resistor, composition 2 K, 1/4 W, 5%	Allen-Bradley	
R-520	241-0229	Resistor, composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-521	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-522	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-523	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-524	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-525	241-0145	Resistor, composition 1 K, 1/4 W, 10%	Allen-Bradley	
R-526	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-527	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-528	240-0052	Resistor, power 1 ohm, 3 W	Allen-Bradley	
R-529	241-0148	Resistor, composition 3.3 K, 1/4 W, 10%	Allen-Bradley	
R-530	241-0148	Resistor, composition 3.3 K, 1/4 W, 10%	Allen-Bradley	
R-531	241-0224	Resistor, composition 8.2 K, 1/4 W, 10%	Allen-Bradley	
R-532	241-0218	Resistor, composition 1.5 K, 1/4 W, 10%	Allen-Bradley	
R-533	241-0230	Resistor, composition 82 ohm, 1/4 W, 10%	Allen-Bradley	
R-534	241-0145	Resistor, composition 1 K, 1/4 W, 10%	Allen-Bradley	
R-535	240-0020	Resistor, non-precision ww 100 ohm, 3 W	Sprague 242E-1015	
R-536	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-537	241-0194	Resistor, composition 4.7 K, 1/4 W, 10%	Allen-Bradley	
R-538	241-0194	Resistor, composition 4.7 K, 1/4 W, 10%	Allen-Bradley	
R-540	241-0144	Resistor, composition 820 K, 1/4 W, 10%	Allen-Bradley	

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
R-541	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-542	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-543	241-0147	Resistor, composition 180 K, 1/4 W, 5%	Allen-Bradley	
T-501	204-0037	Transformer, input	Triad G95113	1
T-502	204-0029	Transformer, interstage	Microtran MT11-FB	1
T-503	202-0052	Transformer, power	Triad #68944	1
TR-501	256-0022	Transistor	Texas Instr. 2N1370	2
TR-502	256-0022	Transistor	Texas Instr. 2N1370	
TR-503	256-0022	Transistor	Texas Instr. 2N1370	
TR-504	256-0022	Transistor	Texas Instr. 2N1370	
TR-505	256-0034	Transistor	Motorola 2N1540	2
TR-506	256-0034	Transistor	Motorola 2N1540	
TR-507	256-0022	Transistor	Texas Instr. 2N1370	
TR-508	256-0022	Transistor	Texas Instr. 2N1370	
TR-509	256-0032	Transistor	Motorola 2N555	2
TR-510	256-0022	Transistor	Texas Instr. 2N1370	
V-501	251-0030	Tube, vacuum, nuvistor	RCA 7586	4

PARTS LIST - Y_2 AMPLIFIER

P/N A-12124
(Refer to Schematic MC-12103)

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
C-501	233-0019	Capacitor, paper .0022 mfd/100 V	C-D Miniroc STM1D22	
C-502	235-0008	Capacitor, tantalum 30 mfd/6 V	Fansteel F-115	
C-503	234-0035	Capacitor, mylar .1 mfd/100 V	Cornell-Dubilier WMF1P1E	
C-504	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-505	231-0020	Capacitor, electrolytic 25 mfd/3 V	Sprague TE-1055	
C-506	231-0020	Capacitor, electrolytic 25 mfd/3 V	Sprague TE-1055	
C-507	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-508	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-509	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-510	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-511	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-512	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-513	234-0035	Capacitor, mylar .1 mfd/100 V	Cornell-Dubilier WMF1P1E	
C-514	231-0080	Capacitor, electrolytic 4 mfd/12 V	Sprague TE-1123	
C-515	234-0035	Capacitor, mylar .1 mfd/100 V	Cornell-Dubilier WMF1P1E	
C-516	234-0035	Capacitor, mylar .1 mfd/100 V	Cornell-Dubilier WMF1P1E	
C-517	234-0047	Capacitor, metallized mylar .5 mfd/400 V	Electrocube 210D1E504J	
C-518	231-0103	Capacitor, electrolytic 20 mfd/50 V	Sprague TE-1305	
C-519	231-0103	Capacitor, electrolytic 20 mfd/50 V	Sprague TE-1305	
C-520	231-0048	Capacitor, electrolytic 1000 mfd/50 V	Sprague TVL-1338	
C-521	231-0077	Capacitor, electrolytic 100 mfd/50 V	Sprague TVL-1317	
C-523	231-0095	Capacitor, electrolytic 50 mfd/10 V	Sprague TE-1119	
C-525	231-0096	Capacitor, electrolytic 250 mfd/12 V	Sprague TE-1138	
CH-501	221-0007	Chopper	Stevens-Arnold BA-11-11	
CR-501	252-0021	Diode	Transitron T12G	
CR-502	252-0021	Diode	Transitron T12G	
CR-503	252-0021	Diode	Transitron T12G	
CR-504	252-0021	Diode	Transitron T12G	
CR-505	250-0022	Diode	Unitrode UZ812	
CR-506	252-0025	Diode	Diodes, Inc. DI-54	
CR-507	252-0025	Diode	Diodes, Inc. DI-54	
CR-508	252-0036	Diode	Solitron HC30	
CR-509	252-0038	Diode	Solitron 50D100A	
CR-510	252-0038	Diode	Solitron 50D100A	
CR-511	250-0015	Diode, zener	HP G-31G12H	
J-601	316-0053	Connector	Amphenol 143-012-01	

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
J-602	316-0044	Connector	Amphenol 143-015-01	
R-501	241-0090	Resistor, composition 1 meg, 1/4 W, 10%	Allen-Bradley	
R-502	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-503	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-504	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-505	241-0159	Resistor, composition 30 K, 1/4 W, 5%	Allen-Bradley	
R-506	241-0137	Resistor, composition 100 ohm, 1/4 W, 5%	Allen-Bradley	
R-507	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-508	241-0146	Resistor, composition 10 K, 1/4 W, 10%	Allen-Bradley	
R-509	241-0157	Resistor, composition 47 K, 1/4 W, 10%	Allen-Bradley	
R-510	241-0224	Resistor, composition 8.2 K, 1/4 W, 10%	Allen-Bradley	
R-511	241-0137	Resistor, composition 100 ohm, 1/4 W, 5%	Allen-Bradley	
R-512	241-0229	Resistor, composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-513	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-514	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-515	241-0227	Resistor, composition 11 K, 1/4 W, 5%	Allen-Bradley	
R-516	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-517	241-0229	Resistor, composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-518	241-0136	Resistor, composition 47 ohm, 1/4 W, 5%	Allen-Bradley	
R-519	241-0228	Resistor, composition 2 K, 1/4 W, 5%	Allen-Bradley	
R-520	241-0136	Resistor, composition 47 ohm, 1/4 W, 5%	Allen-Bradley	
R-521	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-522	241-0229	Resistor, composition 6.2 K, 1/4 W, 5%	Allen-Bradley	
R-523	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-524	241-0149	Resistor, composition 22 K, 1/4 W, 10%	Allen-Bradley	
R-525	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-526	241-0194	Resistor, composition 4.7 K, 1/4 W, 10%	Allen-Bradley	
R-527	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-528	241-0145	Resistor, composition 1 K, 1/4 W, 10%	Allen-Bradley	
R-529	241-0147	Resistor, composition 180 K, 1/4 W, 10%	Allen-Bradley	
R-530	241-0042	Resistor, composition 2.7 K, 1/2 W, 10%	Allen-Bradley	
R-531	240-0052	Resistor, power 1 ohm, 3 W	Allen-Bradley	
R-532	241-0145	Resistor, composition 1 K, 1/4 W, 10%	Allen-Bradley	
R-533	241-0230	Resistor, composition 82 ohm, 1/4 W, 10%	Allen-Bradley	
R-534	241-0218	Resistor, composition 1.5 K, 1/4 W, 10%	Allen-Bradley	
R-535	241-0224	Resistor, composition 8.2 K, 1/4 W, 10%	Allen-Bradley	
R-536	240-0062	Resistor, power 100 ohm, 5 W	Allen-Bradley	
R-537	241-0148	Resistor, composition 3.3 K, 1/4 W, 10%	Allen-Bradley	
R-538	241-0160	Resistor, composition 15 K, 1/4 W, 10%	Allen-Bradley	
R-540	241-0194	Resistor, composition 4.7 K, 1/4 W, 10%	Allen-Bradley	
T-501	204-0037	Transformer, input	Triad G95113	
T-502	204-0029	Transformer, interstage	Microtran MT11-FB	
T-503	202-0052	Transformer, power	Triad 68944	
TR-501	256-0022	Transistor	Texas Instr. 2N1370	
TR-502	256-0022	Transistor	Texas Instr. 2N1370	
TR-503	256-0022	Transistor	Texas Instr. 2N1370	
TR-504	256-0022	Transistor	Texas Instr. 2N1370	
TR-505	256-0053	Transistor, power	Delco	
TR-506	256-0053	Transistor, power	Delco	
TR-507	256-0022	Transistor	Texas Instr. 2N1370	
TR-508	256-0022	Transistor	Texas Instr. 2N1370	
TR-509	256-0053	Transistor, power	Delco	
TR-510	256-0022	Transistor	Texas Instr. 2N1370	
V-501	251-0030	Tube, vacuum, nuvistor	RCA 7586	

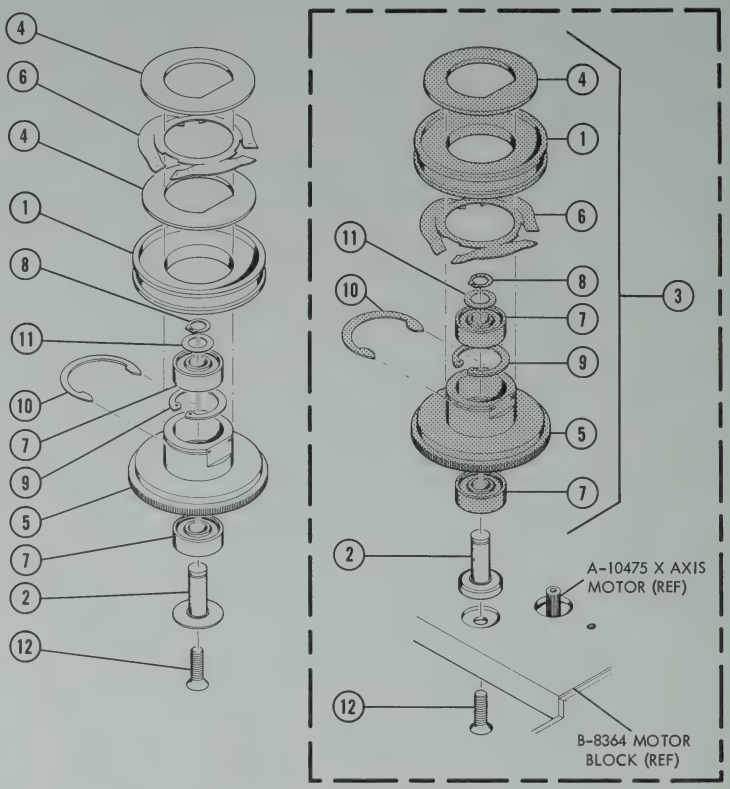
MISCELLANEOUS PARTS

Accessory Kit

A-9423	Syringe - modified (2 ea)	Moseley	2
B-10282	Pen Assembly (2 ea)	Moseley	2
331-0003	Fuse - 3 AG, 3A (5 ea)	Bussman 3PG	

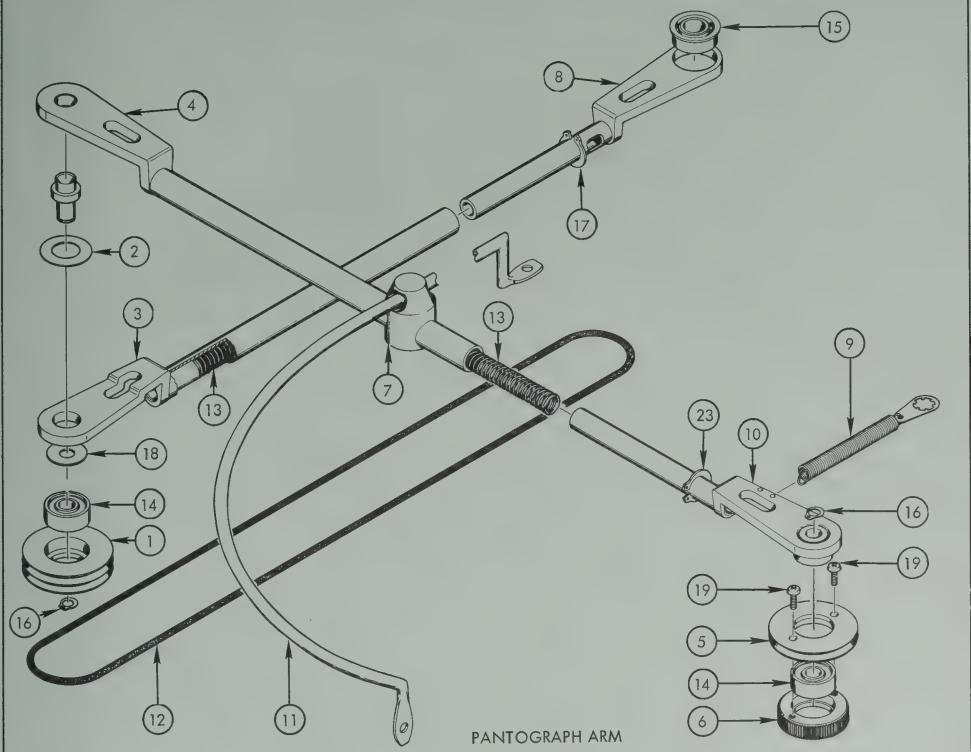
Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
Accessory Kit (Cont)				
	333-0005	Ink - Red	Esterline Angus	A/R
	333-0006	Ink - Green	Esterline Angus	A/R
	376-0005	Wrench	Bristol S-060	1
	376-0006	Wrench	Bristol S-076-4	1
	376-0007	Wrench	Bristol S-094	1
	376-0008	Wrench	Bristol S-110	1
	376-0009	Wrench	Bristol S-048-4	1
	376-0010	Wrench	Bristol S-114	1
	NPN	Wire - piano (1 ft.)		5'
Frame (See figure 5-1)				
	A-6494	Pulley - cable (4 ea)	Moseley	2
	A-6497	Pulley - motor (Y_1)	Moseley	2
	A-8683	Damper - inertia	Moseley	1
	A-9861	Roller - slide (6 ea)	Moseley	3
	A-9862	Bushing - roller (8 ea)	Moseley	
	A-10712	Outlet - exhaust	Moseley	
	A-10764	Tube - inlet and outlet	Moseley	
	A-10778	Cap - muffler (3 ea)	Moseley	
	A-15809	Assy - clutch "X" Axis	Moseley	
	A-5964	Sheave - "X" Clutch Assy	Moseley	
	A-10275	Washer - "X" Clutch Assy	Moseley	
	A-10728	Gear - "X" Clutch Assy	Moseley	
	355-0024	Spring - "X" Clutch Assy	Associated #S-10	
	356-0003	Bearing - "X" Clutch Assy	Fafnir 33KDD5	
	357-0016	Retaining Ring "X" Clutch Assy	Waldes N-5000-37	
	209-0025	Belt - vacuum "V" Type	A. Brown Co. .100X7.8	1
	A-10784-1	Pulley - vacuum pump	Moseley	
	A-10784-2	Pulley - vacuum pump	Moseley	
	A-10844-1	Foam - muffler	Moseley	4
	A-12747	Tube - muffler (2 ea)	Moseley	
	B-8944-1	Stop magnet (R.H.)	Moseley	
	B-8944-2	Stop magnet (L.H.)	Moseley	
	D-11483	Table - vacuum	Moseley	
	209-0004	"O" Ring	Minnesota Rubber & Gasket	3
	209-0008	"O" Ring	Parker 5427-7	3
	209-0016	Belt - vacuum (tooth type)	U.S. Rubber #80XL025	2
	A-10621	Vacuum pump	Gast #0330-V113A	1
	301-0017	Socket - nuvistor	Cinch #133-65-10-001	
	356-0003	Ball bearing	Fafnir #33KDD5	
	380-0128	Fan blade	Torrington #0-327-4	1
	A-6706	Slidewire "X" Axis (up to S/N 198)	Moseley	
Carriage and Associated Parts (See figures 5-3 thru 5-5)				
	A-2091	Bushing - eccentric (2 ea)	Moseley	1
	A-4457	Spring - pen	Moseley	3
	A-9723	Coil - pen	Moseley	
	A-9820	Spring - pen lift	Moseley	1
	A-13428	Spring - pen (modified)	Moseley	1
	355-0036	Spring - compression	Moseley	2
	356-0011	Ball bearing (4 ea)	Microtech #MR5632RPP	2
	A-7856-1	Assy - nylon cable	Moseley	
Pantograph Arm (See figure 5-2)				
	A-1950	Pulley	Moseley	
	A-9822	Spring	Moseley	
	355-0038	Spring (2 ea)	Moseley	

Circuit Symbol	Moseley Part No.	Description	Mfr/Mfrs Designation	RS
Pantograph Arm (See figure 5-2) (Cont)				
	356-0003	Ball bearing	Fafnir #33KDD5	
	356-0032	Ball bearing	New Hampshire #SFR188	
	357-0001	Retaining ring	Tru-Arc #5100-18	
	357-0024	Retaining ring (2 ea)	Waldes #5555-25MD	
	A-7099-1	Assy - Pantograph Arm	Moseley	
	A-8427-1	Assy - Pantograph Arm	Moseley	
	A-7734	Assy Slider Block Pantograph Arm	Moseley	
	A-9831	Assy "Y" Block Pantograph Arm (up to S/N 229)	Moseley	
	360-0114	Washer - Pantograph Arm	Seastrom #A362-33	
	A-16184	Assy "Y" Block Pantograph Arm (S/N 229 & up)		
Miscellaneous				
	228-0004	Graph paper	Gubelmann H-100150	
	228-0005	Graph paper	Gubelmann L-100150	
	391-0001	Slidewire Cleaner & Lubricant	Moseley	
	294-0001	Drive cable	McWhyte	
	380-0115	Cable Crimp		



B/N	Part No.	Description	Mfr/Mfrs Designation	RS
1	A-5964	Sheave-Drive	Moseley	
2	A-6488	Stud-Clutch	Moseley	
3	A-8956	Complete Clutch Assy	Moseley	1
4	A-10275	Washer-Clutch	Moseley	
5	B-10276	Gear-Clutch	Moseley	
6	355-0024	Spring	Associated Spring #S-10	
7	356-0003	Ball Bearing	MRC Type R3FF	
8	357-0001	Retaining Ring-External	Waldes Tru-Arc 5100-18	
9	357-0016	Retaining Ring-Internal	Waldes #N5000-50	
10	357-0021	Retaining Ring		
11	360-0090	Shim 0.005, 3/16 ID x 5/16 OD	Moseley	
12	367-0161	Screw, Flat Hd, 6-32		

FIGURE 7-1. X-AXIS SERVO DRIVE CLUTCH (EXPLODED VIEW)



B/N	Part No.	Description	Mfr/Mfrs Designation	RS
1	A-1950	Pulley	Moseley	
2	360-0114	Washer	Moseley	
3	A-7099-1	Pantograph Arm Assembly	Moseley	
4	A-8427-1	Pantograph Assembly	Moseley	
5	A-6497	Pulley, Motor	Moseley	1
6	A-6498	Gear, "Y" Motor	Moseley	1
7	A-6956	Slider, Pantograph Support	Moseley	1
8	A-7734	Slider Block Assembly	Moseley	
9	A-9822	Spring, Counterbalance	Moseley	1
10	A-9831	"Y" Block Assembly	Moseley	
11	C-6955	Slider Rod, Pantograph Support	Moseley	
12	209-0001-2	Belt	S.S. White 104	
13	355-0038	Spring, Pantograph		2
14	356-0003	Ball Bearing	MRC Type R3FF	2
15	356-0032	Ball Bearing	New Hampshire SFR 188	1
16	357-0001	Retaining Ring	Waldes, TRU-ARC-5100-18	
17	357-0024	Retaining Ring	Waldes, 5555-25MD	
18	360-0033	Washer		
19	366-0007	Screw, Binding Head, 2-56 x 1/4		

FIGURE 7-2. PANTOGRAPH ARM (EXPLODED VIEW)

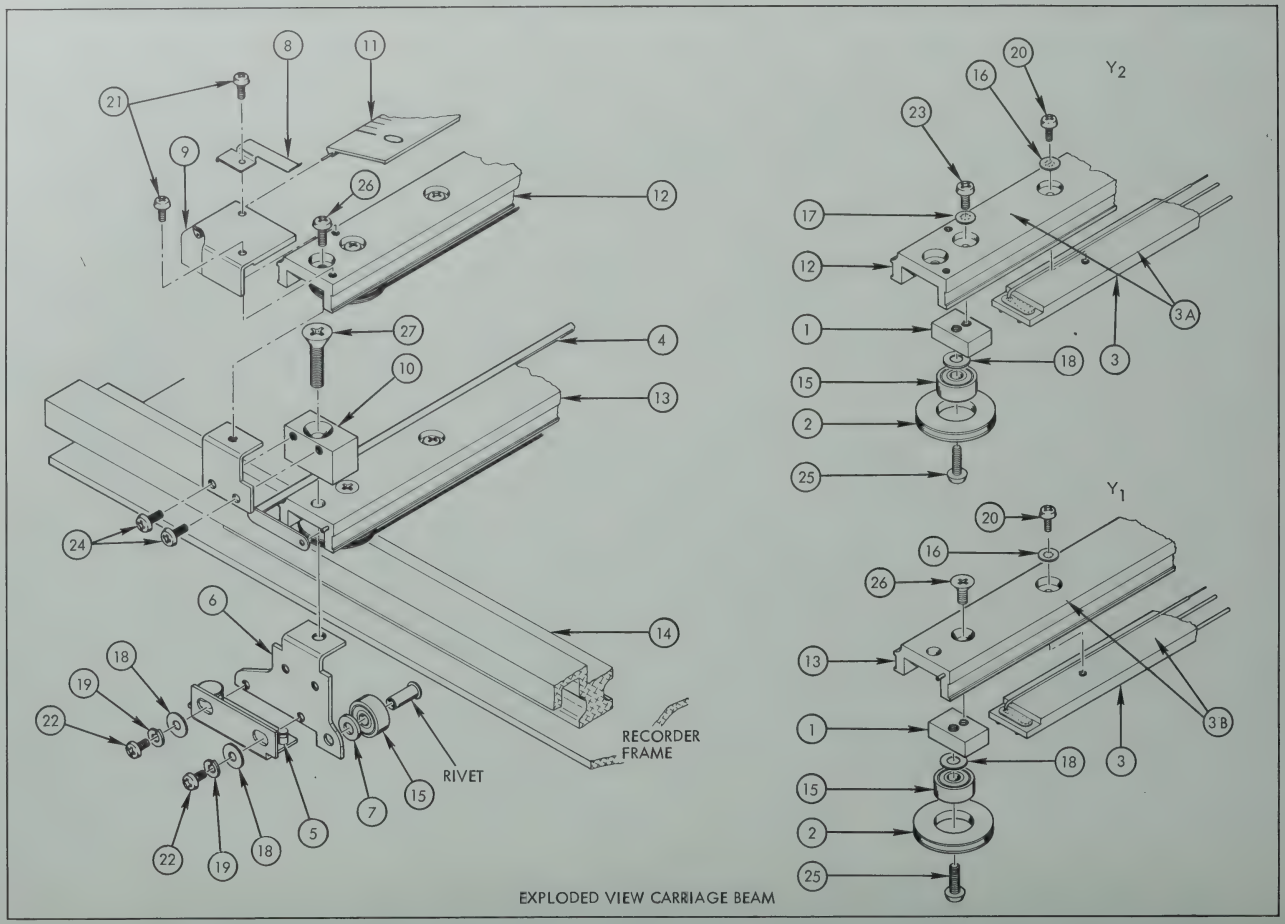


FIGURE 7-3. CARRIAGE ARM (EXPLODED VIEW) (Sheet 1 of 2)

B/N	Part No.	Description	Mfr/Mfrs Designation	RS
1	A-6455	Block, Spacer	Moseley	
2	A-6458	Pulley, Pen Cable	Moseley	
3	A-6712	Y-Slidewire Assembly, up to S/N 198	Moseley	1
3A	M-15206	Slidewire, (Y_2), S/N 198 and up	Moseley	1
3B	M-15724	Slidewire, (Y_1), S/N 198 and up	Moseley	1
4	A-6715	Pen Lift Assembly	Moseley	1
5	A-7090	Assembly Bracket Front Slider	Moseley	
6	A-7774	Slider Block, Lower	Moseley	
7	A-8340	Stud, Front Slider	Moseley	
8	A-8658	Stop, Pen Lift	Moseley	2
9	A-11349	Hinge, Lower (Y_2)	Moseley	
10	A-11370	Mount, Y_2 Arm	Moseley	
11	A-11612	Pen Scale Assembly	Moseley	
	A-13633	Scale and Solenoid (Metric)	Moseley	
12	B-11343	Track, Y_2 Arm, up to S/N 198	Moseley	
13	C-6445	Arm, Pen, up to S/N 198	Moseley	
14	C-6969	Edge, Table	Moseley	
15	356-0004	Ball Bearing	MRC	
16	360-0001	Washer, Lock, Internal Tooth #2	Type #R2FF	2
17	360-0003	Washer, Lock, Internal Tooth #4		
18	360-0030	Washer, Flat, #4		
19	360-0040	Washer, Lock, Split #4		
20	366-0001	Screw, Binder Head, 2-56 x 3/16		
21	366-0004	Screw, Binder Head, 2-56 x 3/16		
22	366-0413	Screw, Binder Head, 4-40 x 3/16		
23	366-0415	Screw, Binder Head, 4-40 x 5/16		
24	366-0432	Screw, Binder Head, 4-40 x 1/4		
25	366-0603	Screw, Binder Head, 5-40 x 5/16		
26	367-0102	Screw, Flat Head, 4-40 x 1/4		
27	367-0155	Screw, Flat Head, 4-40 x 9/16		
28	A-11376	Bracket - Y_2 - Lower	Moseley	

FIGURE 7-3. CARRIAGE ARM (EXPLODED VIEW) (Sheet 2 of 2)

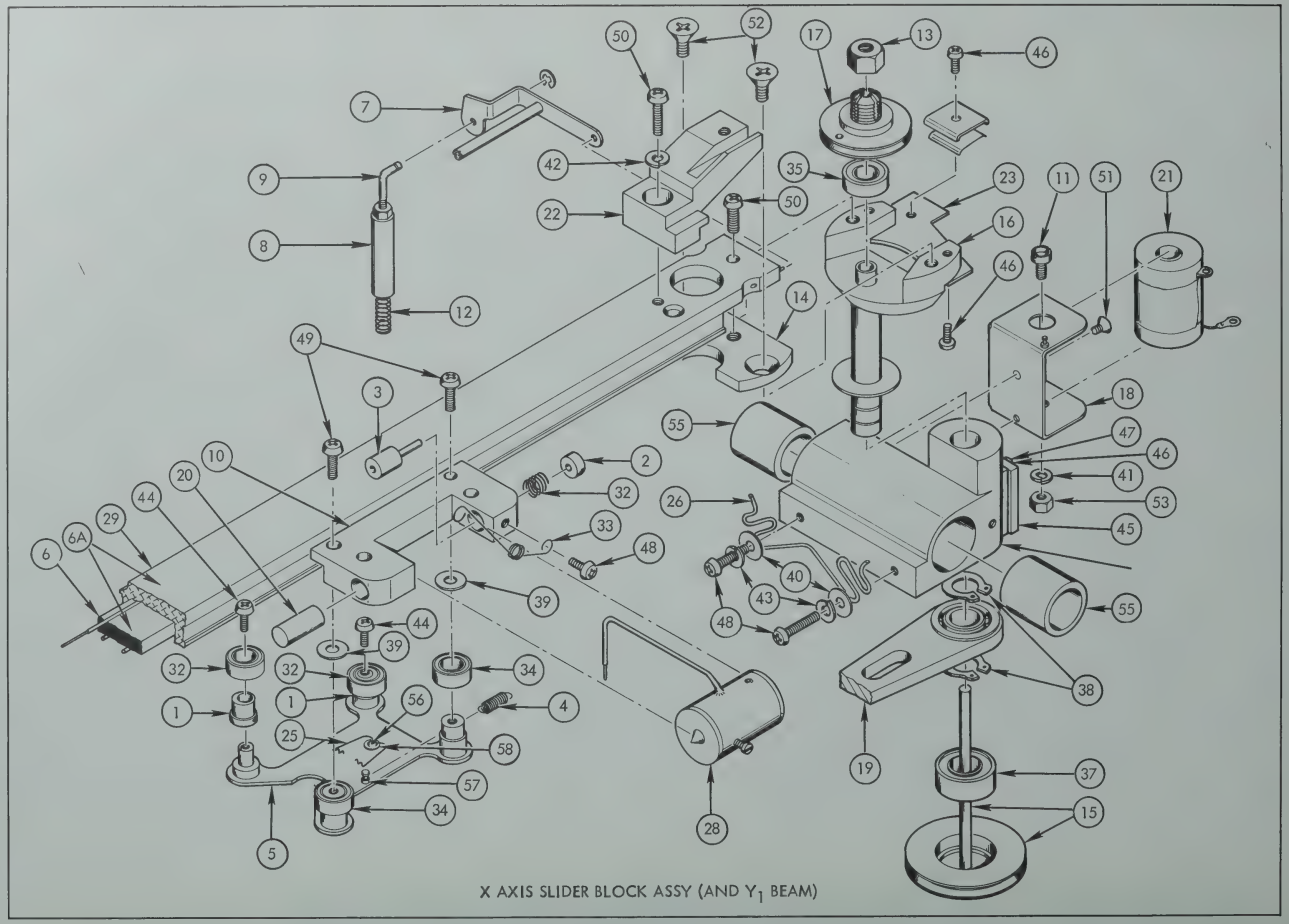


FIGURE 7-4. X-AXIS SLIDER BLOCK ASSEMBLY (AND Y_1 ARM) (Sheet 1 of 2)

B/N	Part No.	Description	Mfr/Mfrs Designation	RS
1	A-2091	Bushing, Eccentric	Moseley	2
2	A-2848	Cap, Spring	Moseley	
3	A-2850	Plunger	Moseley	2
4	A-5961	Spring, Cable	Moseley	2
5	A-8693	Pen Carriage Assembly, up to S/N 198	Moseley	
	M-15217	Pen Carriage Assembly, S/N 198 and up	Moseley	
6	A-6712	Y-axis Slidewire Assembly, up to S/N 198	Moseley	2
6A	M-15724	Y_1 Slidewire, S/N 198 and up	Moseley	
7	A-6715	Pen Lift Bail	Moseley	
8	A-7365	Plunger, Pen Lift	Moseley	1
9	A-7367-1	Arm, Plunger	Moseley	2
10	A-9112	Pen Block Assembly	Moseley	1
11	A-7449	Screw	Moseley	
12	A-7450	Spring, Plunger	Moseley	2
13	A-7642	Nut, Lock	Moseley	
14	A-7643	Plate, Channel	Moseley	
15	A-7647	Pulley and Shaft Assembly	Moseley	
16	A-7648	Channel Yoke and Shaft Assembly	Moseley	
17	A-7646	Pulley, Pen	Moseley	
18	A-7731	Bracket Solenoid Holder	Moseley	
19	A-8545-5	Hinge, Pantograph	Moseley	
20	A-9107	Plug-Pen Block	Moseley	1
21	A-9723	Pen Coil Assembly	Moseley	
22	A-11346	Block, Y_2 Arm	Moseley	
23	A-11380	Bracket, Clamp	Moseley	
25	B-6335	Contact, Wire, "Pot," up to S/N 198	Moseley	4
	M-14911	Contact, Wire, "Pot," S/N and up	Moseley	
26	B-6460	Bracket, Cable	Moseley	
28	B-10282	Pen Assembly	Moseley	2
29	C-6445	Arm, Pen	Moseley	2
30	C-7632	Block, Pen Slider	Moseley	
32	355-0036	Spring, Compression	Moseley	2
33	A-4457	Spring Pen Holddown	Moseley	
34	356-0011	Ball Bearing	Microtech #MR5632 RPP	2
35	356-0030	Ball Bearing	New Hampshire SR-166	
36	356-0032	Ball Bearing	New Hampshire SFR-188	2
37	356-0037	Ball Bearing	New Hampshire SR 1883	1
38	357-0024	Retaining Ring	Waldes #5555-25MD	2
39	360-0030	Washer, Flat, #4		
40	360-0036	Washer, Flat, #2		
41	360-0040	Washer, Lock, Split, #4		
42	360-0061	Washer, Lock, Split, #6		
43	360-0078	Washer, Lock, Split, #2		
44	366-0001	Screw, Binder Head, 2-56 x 3/16		
45	A-1937-X	Wiper, up to S/N 198	Moseley	
	M-15198	Wiper, S/N 198 and up	Moseley	
46	366-0002	Screw, Binder Head, 2-56 x 1/8		
47	360-0001	Lock Washer	Moseley	
48	366-0005	Screw, Binder Head, 2-56 x 1/4		
49	366-0825	Screw, Binder Head, 4-40 x 5/16		
50	366-0821	Screw, Binder Head, 6-32 x 7/16		
51	367-0003	Screw, Flat Head, 2-56 x 1/8		
52	367-0162	Screw, Flat Head, 6-32 x 1/4		
53	383-0005	Nut, Ratio #4		
55	385-0022	Bushing	Boston #B-68-4	
56	237-0002	Component Ilet, 1/16 x 3/32	Circon CE44	
57	312-0037	Terminal	Lerco 5090-B	
58	360-0035	Washer, Flat, Brass #0		

FIGURE 7-4. X-AXIS SLIDER BLOCK ASSEMBLY (AND Y_1 ARM) (Sheet 2 of 2)

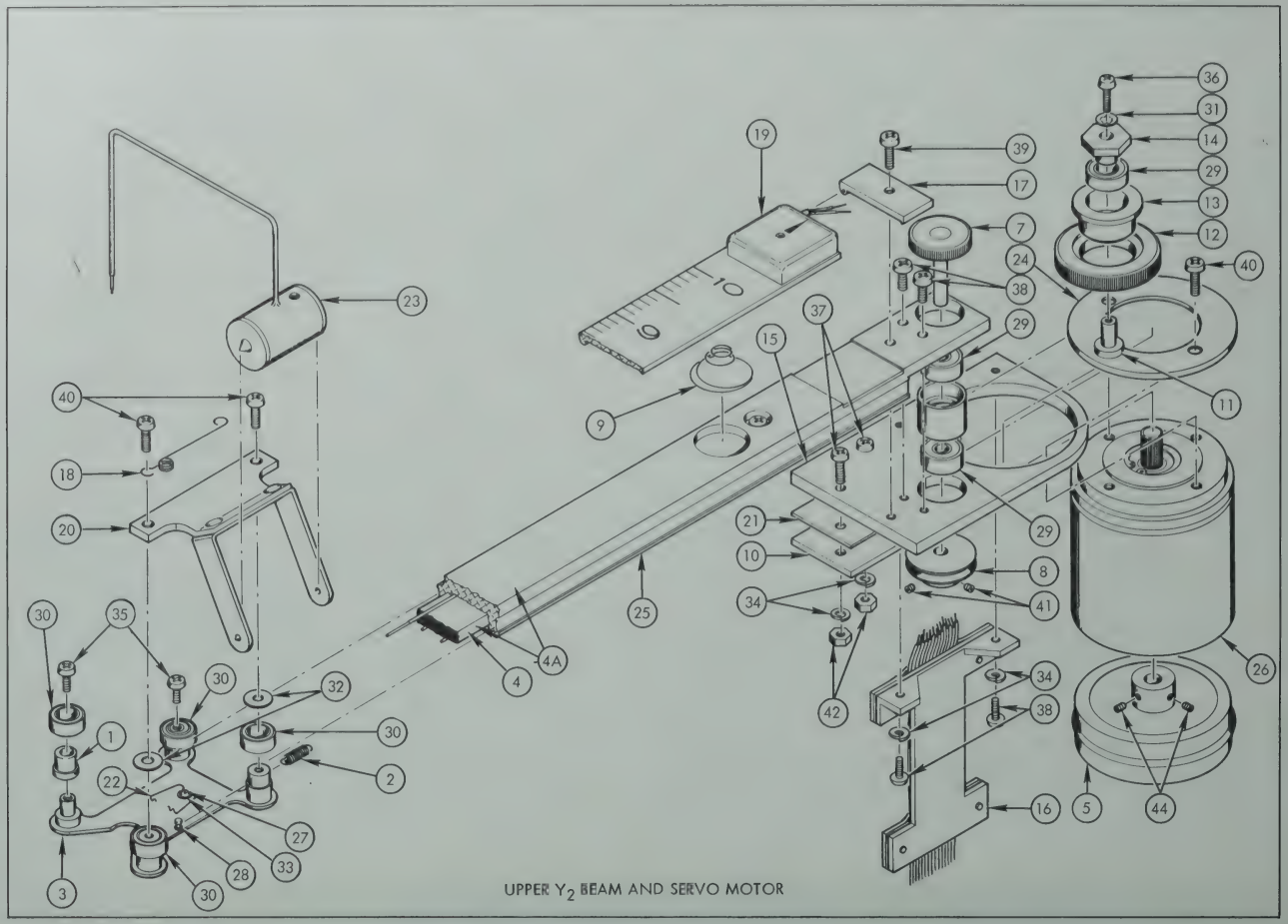
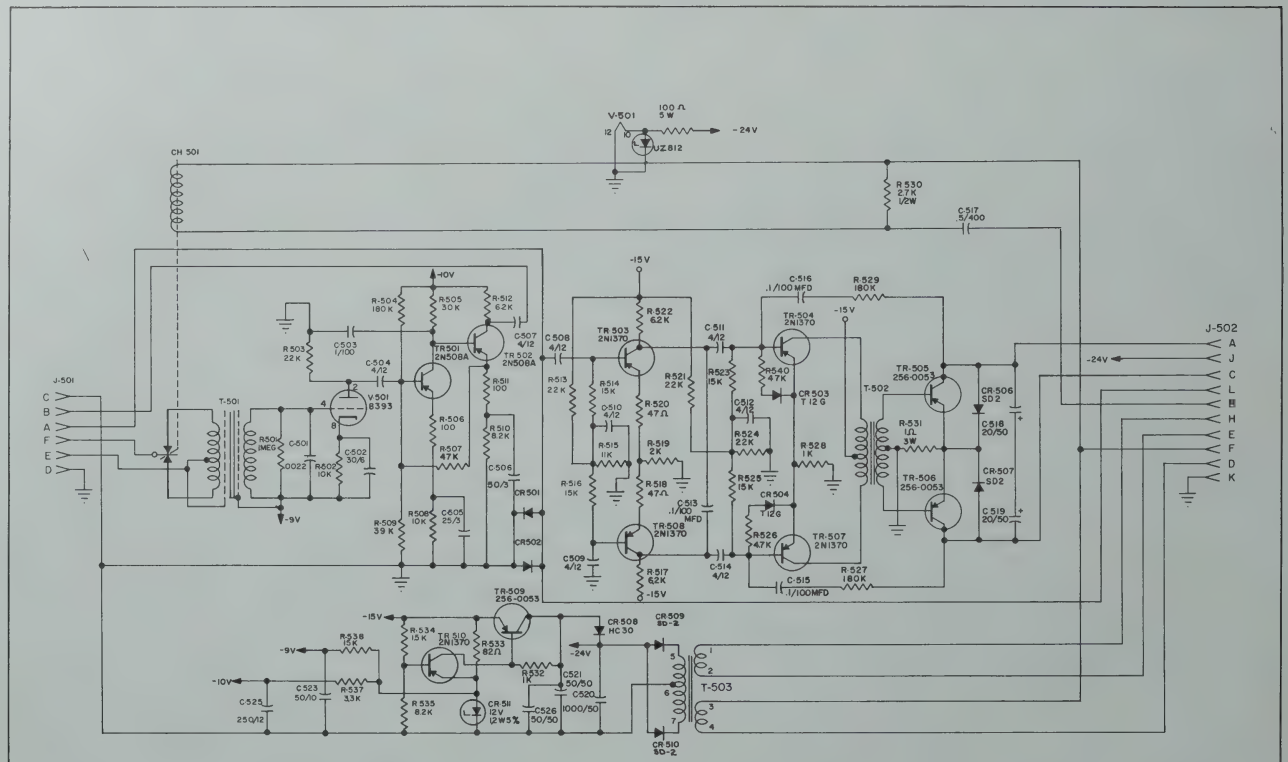


FIGURE 7-5. UPPER Y_2 ARM AND SERVO MOTOR (Sheet 1 of 2)

B/N	Part No.	Description	Mfr/Mfrs Designation	RS
1	A-2091	Bushing, Eccentric	Moseley	2
2	A-5961	Spring, Cable	Moseley	2
3	A-8693	Complete Pen Carriage Assembly, up to S/N 198	Moseley	
	M-15217	Complete Pen Carriage Assembly, S/N 198 and up	Moseley	
4	A-6712	Y-axis Slidewire, up to S/N 198	Moseley	1
4A	M-15206	Slidewire Assembly, S/N 198 and up	Moseley	
5	A-8683	Inertia, Damper	Moseley	1
6	A-9444	Housing, Bearing	Moseley	
7	A-9454	Drive Gear Y_2 Assembly	Moseley	
8	A-9498	Pulley, Upper	Moseley	
9	A-9820	Spring, Pen Lift	Moseley	2
10	A-10052	Terminal Board	Moseley	
11	A-11338	Shaft, Bearing	Moseley	
12	A-11339	Gear, Modified, up to S/N 168	Moseley	1
	A-14456	Gear-Idler, S/N 168 and up	Moseley	
13	A-11340	Enclosure, Bearing, up to S/N 168	Moseley	
	A-14456	Gear-Idler S/N 168 and up	Moseley	
14	A-11341	Bushing, Eccentric	Moseley	2
15	A-11344	Block, Motor Y_2		
16	A-11345	Bracket, Cable Guide	Moseley	
17	A-11350	Hinge, Upper	Moseley	
18	A-4457	Spring, Pen Holder		
19	A-11612	Solenoid, Pen Lift	Moseley	2
	A-13633	Solenoid, Pen Lift (Metric)	Moseley	
20	B-11377	Mount, Pen Holder	Moseley	
21	A-12224	Insulator, Terminal Board		
22	B-6335	Contact Wire, "Pot"	Moseley	3
	M-14911	Contact Wire, "Pot," S/N 198 and up	Moseley	
23	B-9373	Pen, Auxiliary	Moseley	1
24	B-9441	Retainer, Motor	Moseley	
25	B-11343	Track, Y_2 Arm, up to S/N 198	Moseley	
26	227-0022	Servo Motor, Modified	Daystrom	
27	237-0002	Component Eyelet	Circon CE44	
28	312-0037	Terminal	Lerco 5090-B	
29	356-0004	Ball Bearing	MRC Type #R2FF	
30	356-0011	Ball Bearing	Microtech MR5632RPP	2
31	360-0001	Washer, Lock Internal Tooth, #2		
32	360-0030	Washer, Flat, #4		
33	360-0035	Washer, Flat, Brass, #0		
34	360-0040	Washer, Lock, Split, #4		
35	366-0001	Screw, Binder Head, 2-56 x 3/16		
36	366-0007	Screw, Binder Head, 2-56 x 5/16		
37	366-0204	Screw, Binder Head, 3-48 x 3/8		
38	366-0407	Screw, Binder Head, 4-40 x 1/4		
39	366-0411	Screw, Binder Head, 4-40 x 1/2		
40	366-0415	Screw, Binder Head, 4-40 x 5/16		
41	375-0041	Set Screw, 2-56 x 1/4		
42	383-0010	Nut, Hex, 3-48 NC-2		

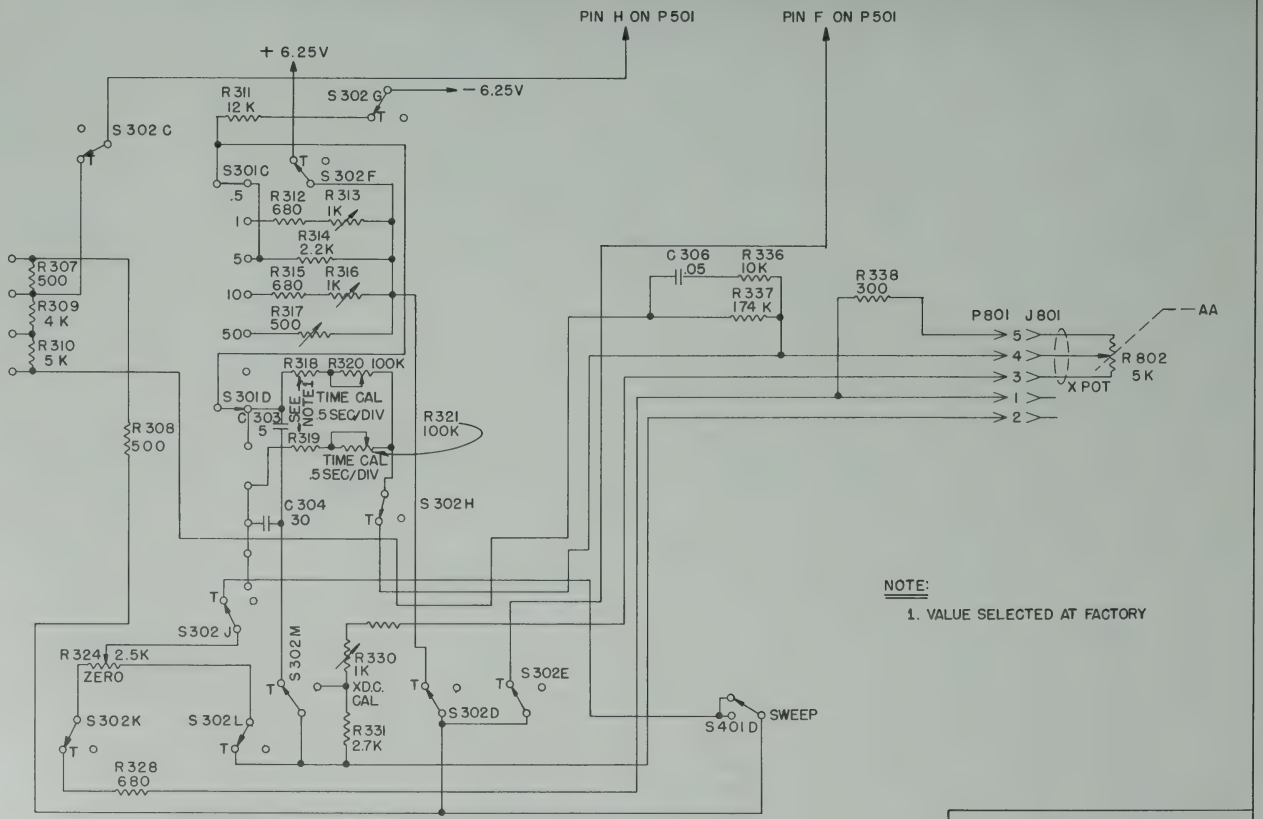
FIGURE 7-5. UPPER Y_2 ARM AND SERVO MOTOR (Sheet 2 of 2)

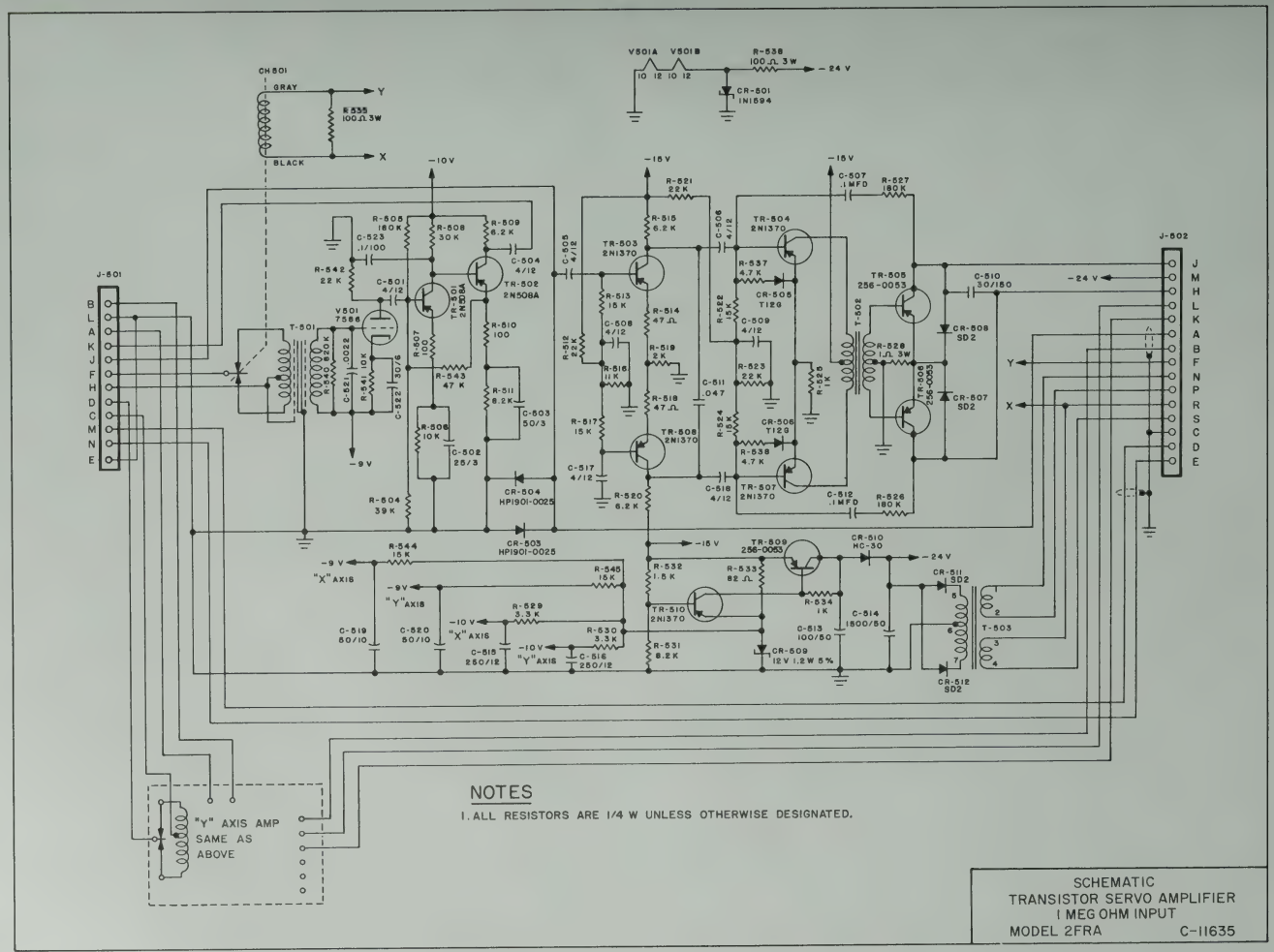


NOTES

ALL RESISTORS ARE 1/4 WATT UNLESS OTHERWISE NOTED

SCHEMATIC
TRANSISTOR SERVO AMPLIFIER
MODEL 2FRA C-12103

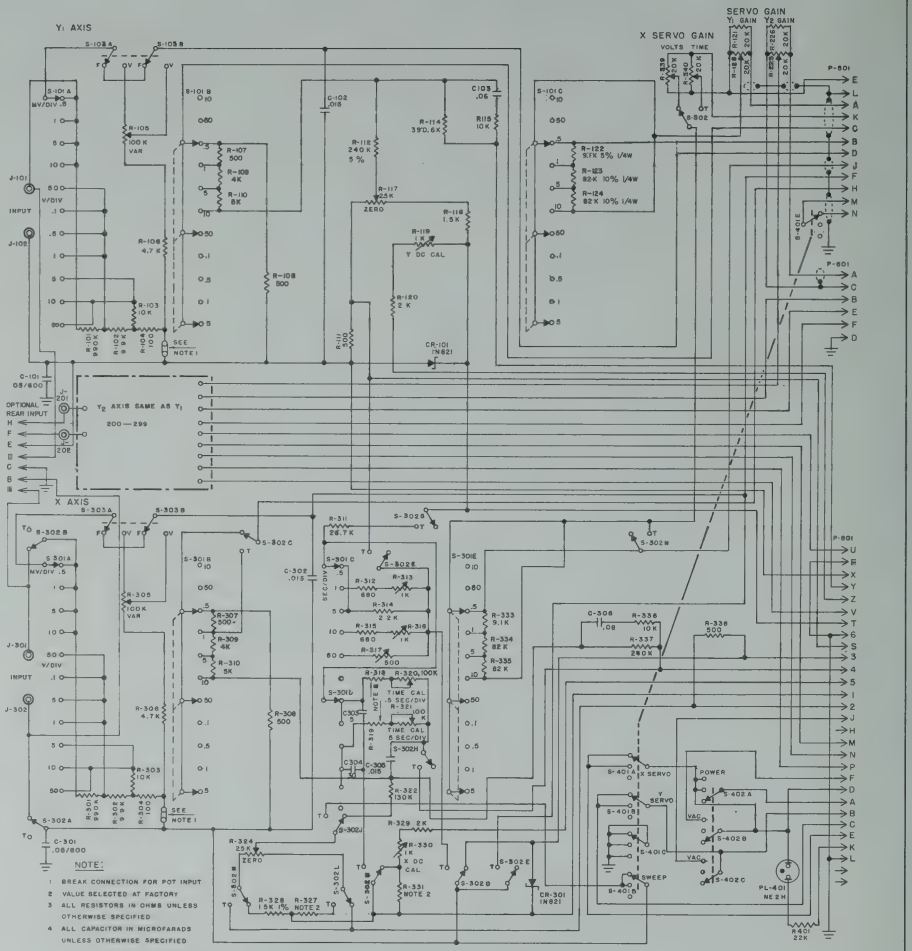

PIN H ON P501
PIN F ON P501
+ 6.25V
R311 12 K
S 302 G
- 6.25V
S 302 C
S301C
S 302 F
.5
1
5
10
50
R 312 680
R 313 1K
R 314 2.2K
R 315 680
R 316 1K
R 317 500
R 307 500
R309 4 K
R 310 5 K
R 308 500
R 318
R320 100K
S 301D
TIME CAL 5 SEC/DIV
SWEEP
C 303 5
R 319
R321 100K
TIME CAL .5SEC/DIV
C 304 30
S 302 H
S 302 J
S 302 M
R 324 2.5K ZERO
S 302K
S 302L
R 328 680
R330 1K X.D.C. CAL
R331 2.7K
S 302D
S 302E
S 401 D
SWEEP
C 306 .05
R 336 10K
R 337 174 K
R 338 300
P801 J801
5
4
3
1
2
R 802 5K
X POT
AA
NOTE:
1. VALUE SELECTED AT FACTORY
SCHEMATIC
TIME SWEEP CIRCUIT
MODEL 2FRA C-13714

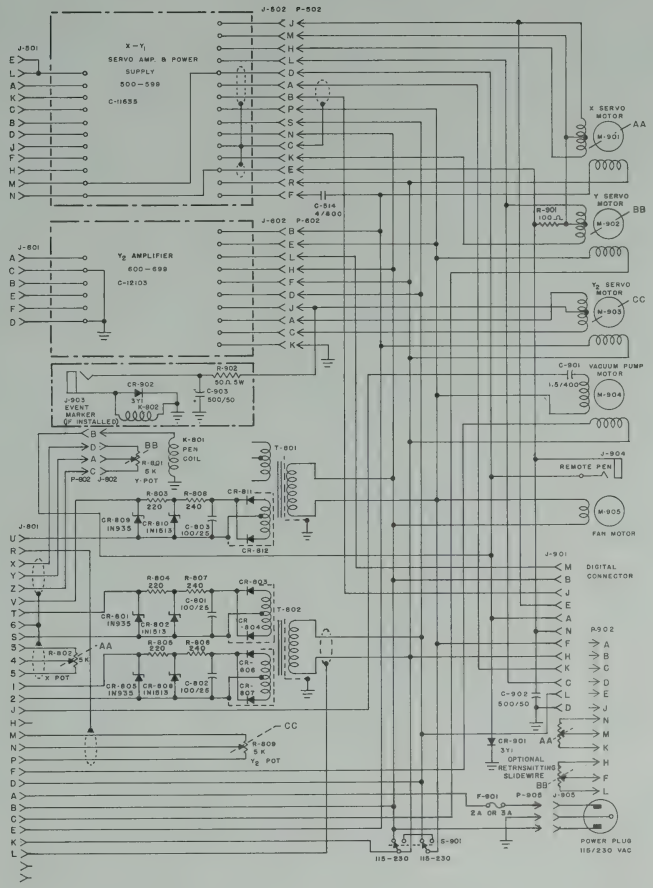


NOTES

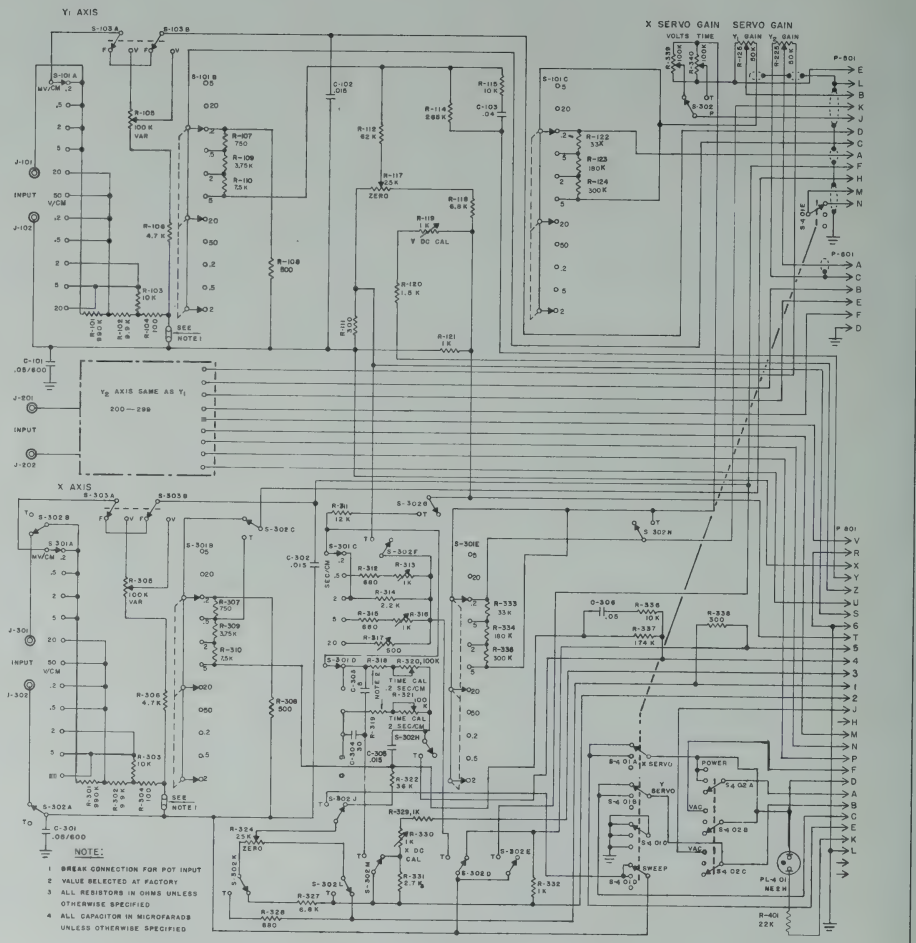
1. ALL RESISTORS ARE 1/4 W UNLESS OTHERWISE DESIGNATED.

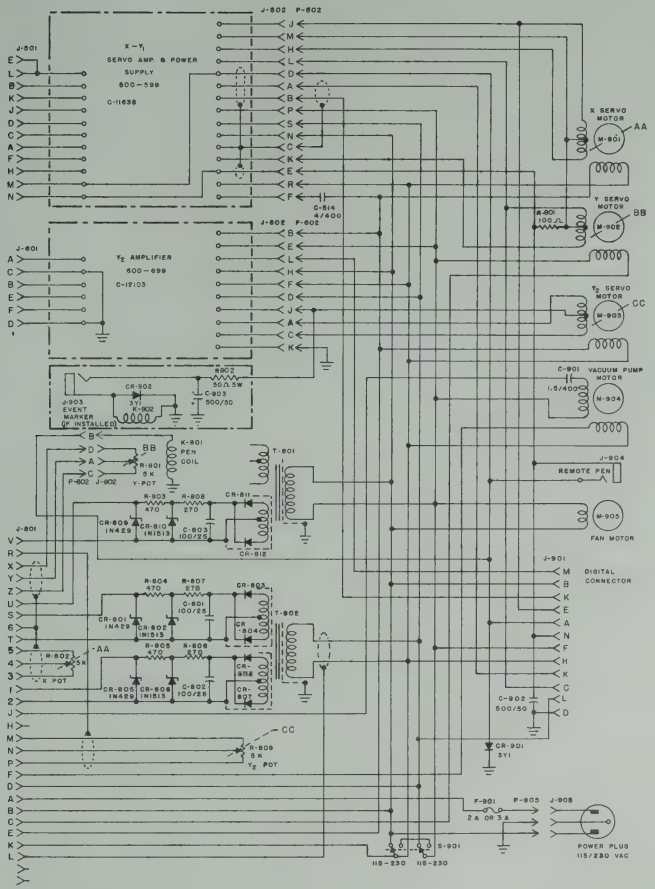
SCHEMATIC
TRANSISTOR SERVO AMPLIFIER
1 MEG OHM INPUT
MODEL 2FRA C-11635


Y1 AXIS
X AXIS
SERVO GAIN
Y1 GAIN
Y2 GAIN
X SERVO GAIN
VOLTS
TIME
Y2 AXIS SAME AS Y1
200—299
OPTIONAL REAR INPUT
INPUT
V/DIV
MV/DIV
SEC/DIV
Y DC CAL
TIME CAL .5 SEC/DIV
TIME CAL 5 SEC/DIV
X SERVO
Y SERVO
POWER
SWEEP
VAC
NE2H
SEE NOTE 1
NOTE:
1 BREAK CONNECTION FOR POT INPUT
2 VALUE SELECTED AT FACTORY
3 ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
4 ALL CAPACITOR IN MICROFARADS UNLESS OTHERWISE SPECIFIED



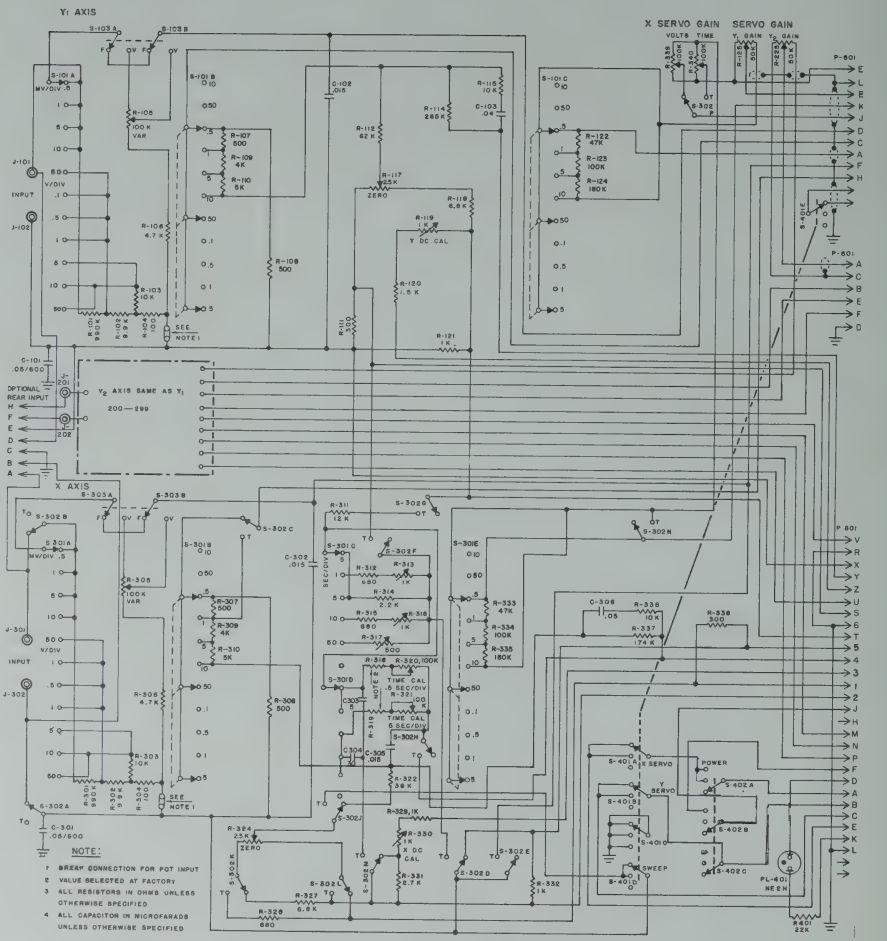
SCHEMATIC
MODEL 2FRA (WITHOUT AUTOGRIP)
D-12607

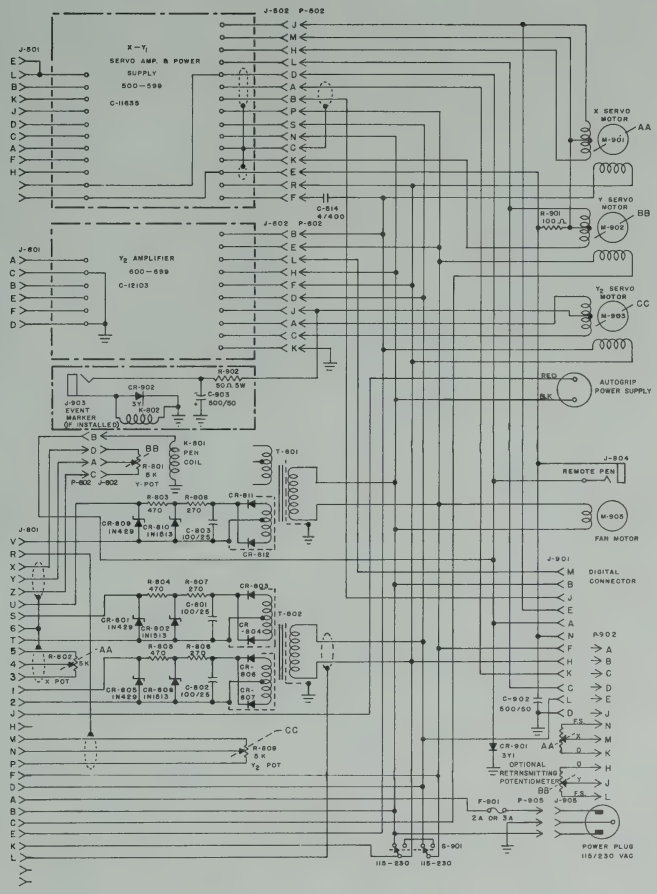

Y1 AXIS
X SERVO GAIN
SERVO GAIN
VOLTS TIME
Y1 GAIN
Y2 GAIN
P-501
INPUT
J-101
J-102
J-201
J-202
J-301
J-302
Y2 AXIS SAME AS Y1
200 — 299
X AXIS
SEE NOTE 1
NOTE:
1 BREAK CONNECTION FOR POT INPUT
2 VALUE SELECTED AT FACTORY
3 ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
4 ALL CAPACITOR IN MICROFARADS UNLESS OTHERWISE SPECIFIED
X SERVO
Y SERVO
SWEEP
POWER
PL-401 NEEH



2FRAM

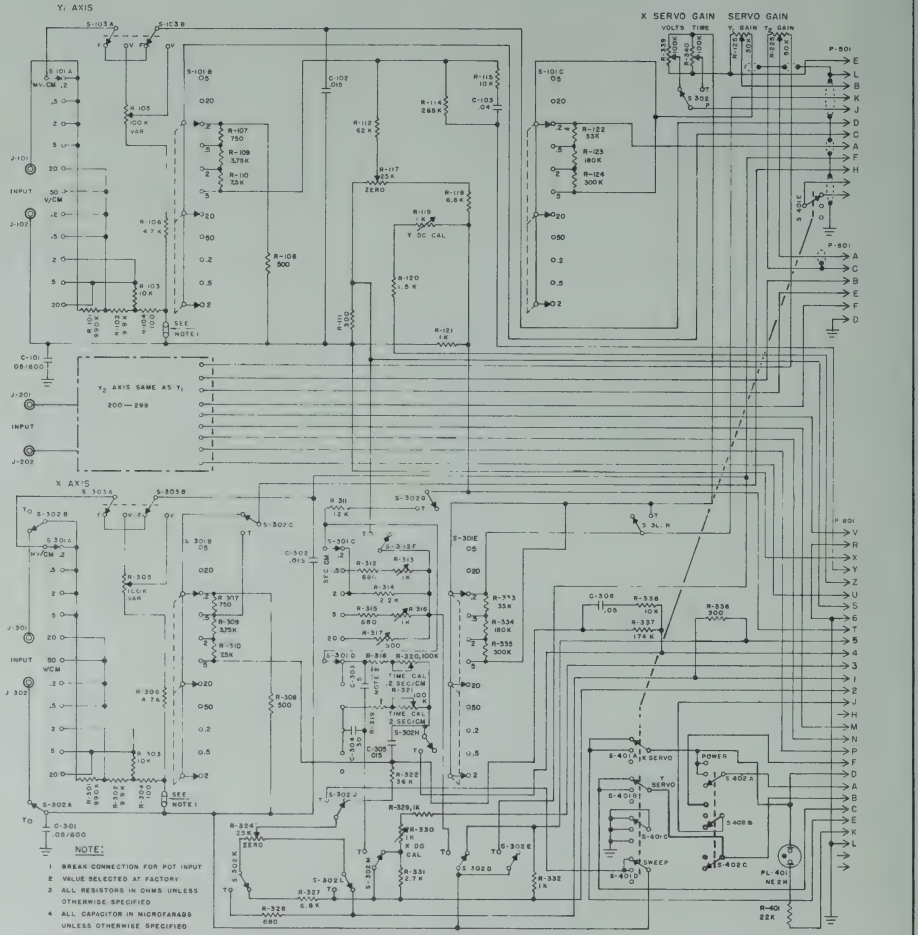
SCHEMATIC
MODEL 2FRAM (WITHOUT AUTOGRIP)
D-13520

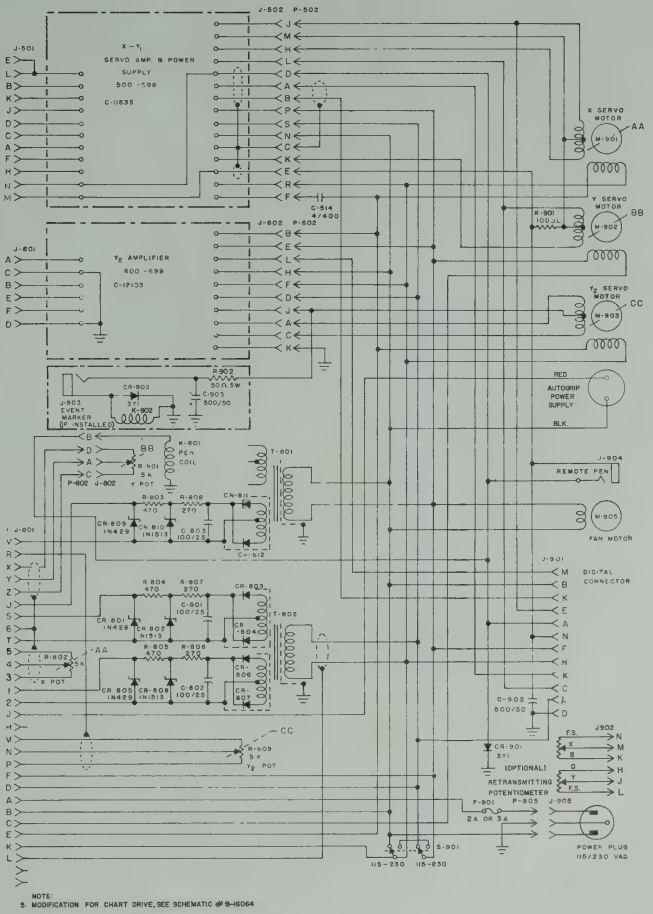

Y1 AXIS
X SERVO GAIN
SERVO GAIN
X AXIS
OPTIONAL REAR INPUT
Y2 AXIS SAME AS Y1
200 — 299
INPUT
MV/DIV
V/DIV
SEE NOTE 1
Y DC CAL
X DC CAL
TIME CAL .5 SEC/DIV
TIME CAL 5 SEC/DIV
ZERO
X SERVO
Y SERVO
POWER
SWEEP
NOTE:
1 BREAK CONNECTION FOR POT INPUT
2 VALUE SELECTED AT FACTORY
3 ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
4 ALL CAPACITOR IN MICROFARADS UNLESS OTHERWISE SPECIFIED



5. MODIFICATION FOR CHART DRIVE, SEE SCHEMATIC # B-16064

SCHEMATIC
ELECTROSTATIC HOLD-DOWN
MODEL 2FRA D-15034


Y1 AXIS
X SERVO GAIN
SERVO GAIN
VOLTS
TIME
Y GAIN
Y2 GAIN
INPUT
Y2 AXIS SAME AS Y1
200—299
X AXIS
P-501
P-601
NOTE:
1 BREAK CONNECTION FOR POT INPUT
2 VALUE SELECTED AT FACTORY
3 ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
4 ALL CAPACITOR IN MICROFARADS UNLESS OTHERWISE SPECIFIED



NOTE:
5. MODIFICATION FOR CHART DRIVE, SEE SCHEMATIC # B-16064

SCHEMATIC
2FRAM (WITH AUTOGRIP)
D-16131

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TWX: 216-888-0715

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HEWLETT hp PACKARD

MANUAL CHANGES

2FRA/2FRAM
TWO PEN RECORDER
Includes MODEL 2FR
Manual Printed: February 1965

Make all corrections in this manual according to errata below, then check the following table for your instrument serial prefix (3 digits) or serial number (8 digits) and make any listed change(s) in the manual.

*NEW ITEM

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES
610	I
* 619	I II

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES

ERRATA

Pen lift is designed for optimum operation with instrument in vertical position. For operation in the horizontal position, use the Model 2FA bench type unit which has optimum performance in the horizontal plane.

CHANGE I

Section VII

Change the description of the following parts under the heading "PARTS LIST CONTROL BOX AND MECHANICAL ASSEMBLY" (Do not include parts for metric models).

C-103	----------	Factory selected value	
C-203	----------	Factory selected value	
C-306	----------	Factory selected value	
CR-101	1902-0777	Diode, Zener, 5.9 to 6.3V	Transistron IN825
CR-201	1902-0777	Diode, Zener, 5.9 to 6.3V	Transistron IN825
CR-301	1902-0777	Diode, Zener, 5.9 to 6.3V	Transistron IN825
CR-801	1902-0786	Diode, Zener, 9.0V±5%	Transistron IN825
CR-802	250-0030	Diode, Zener	Sylvania #169126
CR-805	1902-0786	Diode, Zener, 9.0V±5%	Transistron IN825

Change C for 9320-1305

July 1, 1966

CR-808	250-0030	Diode, Zener	Sylvania #169126
CR-809	1902-0786	Diode, Zener, 9.0V± 5%	Transitron IN937
CR-810	250-0030	Diode, Zener	Sylvania #169126
R-112	241-0249	Resistor, Composition 180K, 1/4W, 5%	Allen Bradley
R-115	0684-8231	Resistor, Composition 82K, 1/4W, 10%	Allen Bradley
R-118	243-0327	Resistor, WW, 2K, 1%	Cinema CE542E
R-120	243-0412	Resistor, WW, 1.5K, 1%	Cinema CE542E
R-122	241-0322	Resistor, Composition 9.1K, 1/4W, 5%	Allen Bradley
R-123	241-0238	Resistor, Composition 82K, 1/4 W, 10%	Allen Bradley
R-124	241-0238	Resistor, Composition 82K, 1/4W, 10%	Allen Bradley
R-125	236-0075	Resistor, Variable, 20K	CTS UPE-70
R-126	241-0237	Resistor, Composition 20K, 1/4W, 5%	Allen Bradley
R-212	241-0249	Resistor, Composition 180K, 1/4W, 5%	Allen Bradley
R-215	0684-8231	Resistor, Composition 82K, 1/4W, 10%	Allen Bradley
R-218	243-0327	Resistor, WW, 2K, 1%	Cinema CE542E
R-220	243-0412	Resistor, WW, 1.5K, 1%	Cinema CE542E
R-222	241-0322	Resistor, Composition 9.1K, 1/4W, 10%	Allen Bradley
R-223	241-0238	Resistor, Composition 82K, 1/4W, 5%	Allen Bradley
R-226	241-0237	Resistor, Variable, 20K	CTS UPE-70

R-329	243-0458	Resistor, WW, 1.7K, 1%	Cinema CE542E
R-333	241-0322	Resistor, Composition 9.1K, 1/4W, 5%	Allen Bradley
R-334	241-0238	Resistor, Composition, 82K, 1/4W, 5%	Allen Bradley
R-335	241-0238	Resistor, Composition 82K, 1/4W, 5%	Allen Bradley
R-336	0684-4731	Resistor, Composition 47K, 1/4W, 10%	Allen Bradley
R-338	243-0427	Resistor, WW, 500 ohm, 1%	Cinema CE542
R-339	236-0075	Resistor, Variable, 20K	CTS UPE-70
R-340	236-0075	Resistor, Variable, 20K	CTS UPE-70
R-801	M-15724	Resistor, Y-axis, Rebalance 5K	Moseley
R-802	M-15207	Resistor, X-axis Rebalance 5K	Moseley
R-809	M-15206	Resistor, Yz-axis Rebalance 5K	Moseley
R-901	240-0019	Resistor, 50 ohm, 5W	Clarostat V5F

Change the description of the following parts under the heading "PARTS LIST CONTROL BOX AND MECHANICAL ASSEMBLY" (metric model only).

R-122	241-0263	Resistor, Composition 18K, 1/4W, 5%	Allen Bradley
R-123	241-0307	Resistor, Composition 9.1K, 1/4W, 5%	Allen Bradley
R-124	241-0293	Resistor, Composition 150K, 1/4W, 5%	Allen Bradley
R-222	241-0263	Resistor, Composition 18K, 1/4W, 5%	Allen Bradley
R-223	241-0307	Resistor, Composition 91K, 1/4W, 5%	Allen Bradley

R-224	241-0293	Resistor, Composition 150K, 1/4W, 5%	Allen Bradley
R-333	241-0263	Resistor, Composition 18K, 1/4W, 5%	Allen Bradley
R-334	241- 0307	Resistor, Composition 91K, 1/4W, 5%	Allen Bradley
R-335	241-0293	Resistor, Composition 150K, 1/4W, 5%	Allen Bradley

Under the heading "PARTS LIST-X AND Y, AMPLIFIERS", Change the following.

P/N M-18074
(Refer to schematic D-18066)

C-503	231-0070	Capacitor, Electrolytic 50mfd, 100V	Sprague 30D506G003BB4
C-510	234-0032	Capacitor, Metalized mylar 0.5mfd, 100V	Electron M1-504
C-520	234-0032	Capacitor, Metalized mylar 0.5mfd, 100V	Electron M1-504
R-536	240-0064	Resistor, 75ohm, 5W	Sprague 243E
R-543	241-0257	Resistor, Composition 47K, 1/4W, 10%	Allen Bradley
TR-501	256-0055	Transistor, 2N 508A	G E 30002
TR-502	256-0055	Transistor, 2N 508A	G E 30002

Add the following:

C-523	234-0035	Capacitor, 0.1mfd, 100V	C-D #WMF 1 PIE
C-524	231-0095	Capacitor, Electrolytic 50mfd, 10V	Sprague
R-544	241-0160	Resistor, Composition 15K, 1/4W, 10%	Allen Bradley
R-545	241-0160	Resistor, Composition 15K, 1/4W, 10%	Allen Bradley

R-546	241-0146	Resistor, Composition 10K, 1/4W, 10%	Allen Bradley
R-547	241-0146	Resistor, Composition 10K, 1/4W, 10%	Allen Bradley

Under the heading "PARTS LIST - Y_2 AMPLIFIER", Change the following:

P/N M-18074
(Refer to schematic D-18067)

C-506	231-0070	Capacitor, Electrolytic 50mfd, 3V	Sprague TE 1050
C-518	234-0032	Capacitor, Metalized 0.5mfd, 100V	Electron M1-504
C-519	234-0032	Capacitor, Metalized 0.5mfd, 100V	Electron M1-504
C-521	231-0087	Capacitor, Electrolytic 50mfd, 50V	Sprague TE 1307
R-532	241-0180	Resistor, Composition 3.9K, 1/4W, 10%	Allen Bradley
TR-501	256-0055	Transistor, 2N508A	G E 30002
TR-502	256-0055	Transistor, 2N508A	G E 30002

Add the following:

C-526	231-0087	Capacitor, Electrolytic 50mfd, 50V	Sprague 30D506G0500H4
R-542	241-0146	Resistor, Composition 10K, 1/4W, 10%	Allen Bradley
R-541	241-0146	Resistor, Composition 10K, 1/4W, 10%	Allen Bradley

Pages 7-18, 7-21- and 7-26 through 7-29, Replace schematics:

Was	Replaced by
C-12103	C-18067-B
C-11635	C-18066-B
D-15034	D-16686-F
D-16131	D-18164-E

CHANGE II

Page 7-4, Change R-902 to read as follows:

R-902	240-0050	Resistor, Power, 150 ohm, 5w	Sprague	243E

Page 7-3, Change R-320 and R-321 to read as follows:

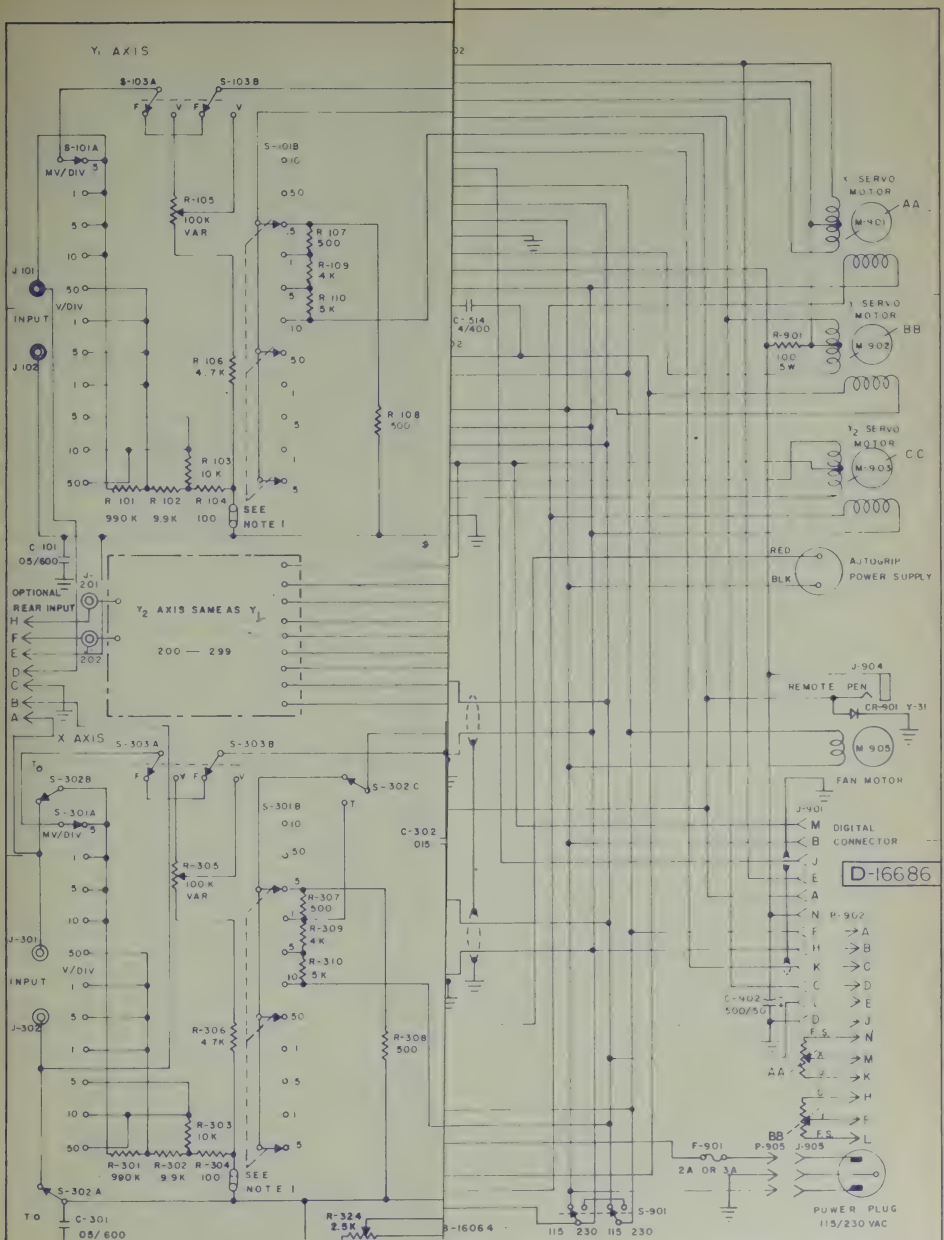
R-320	2100-0144	Resistor, Variable, 250K	CTS	UPM7ORE
R-321	2100-0144	Resistor, Variable, 250K	CTS	UPM7ORE

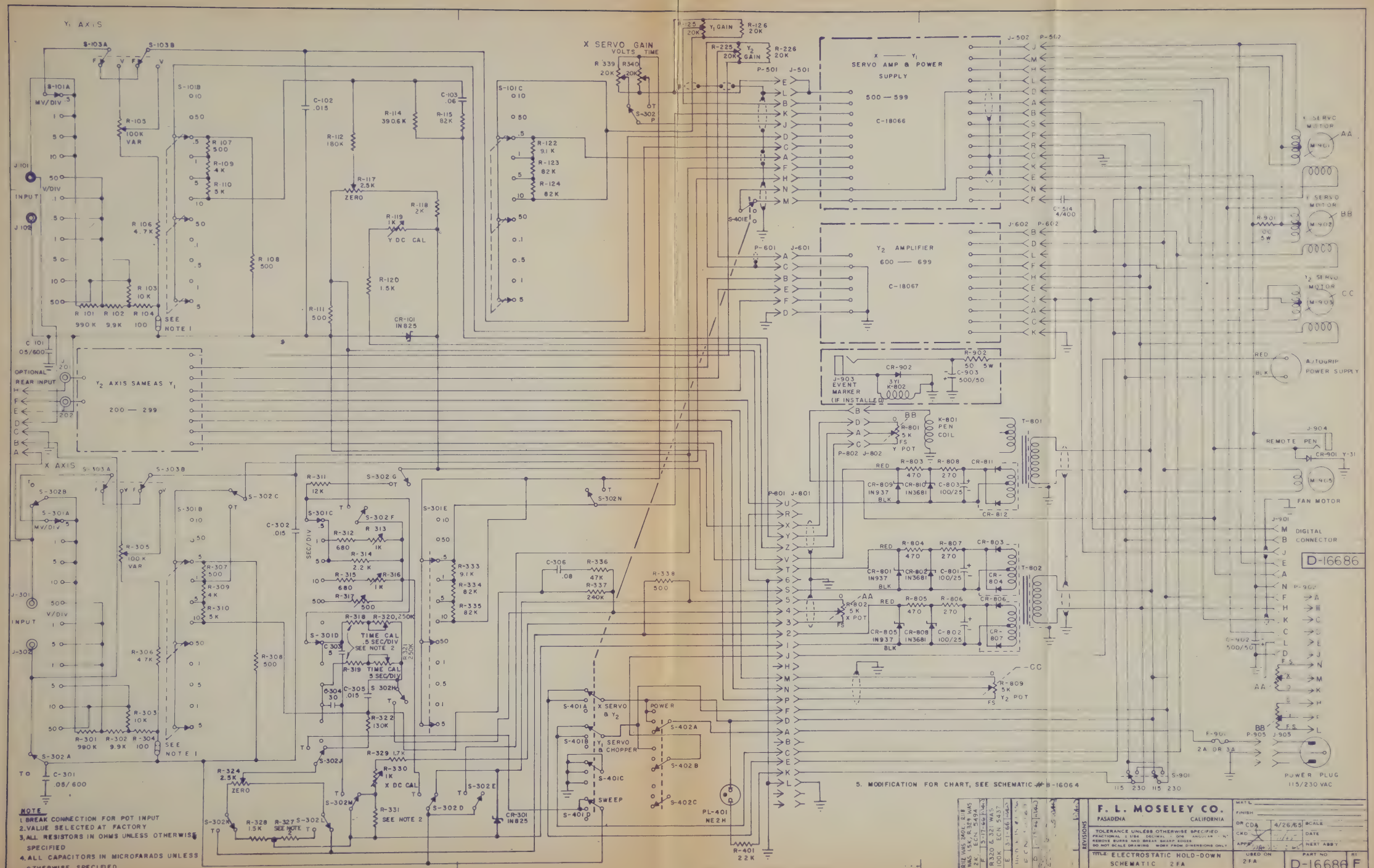
Page 7-15, Change B/N 55 to read as follows:

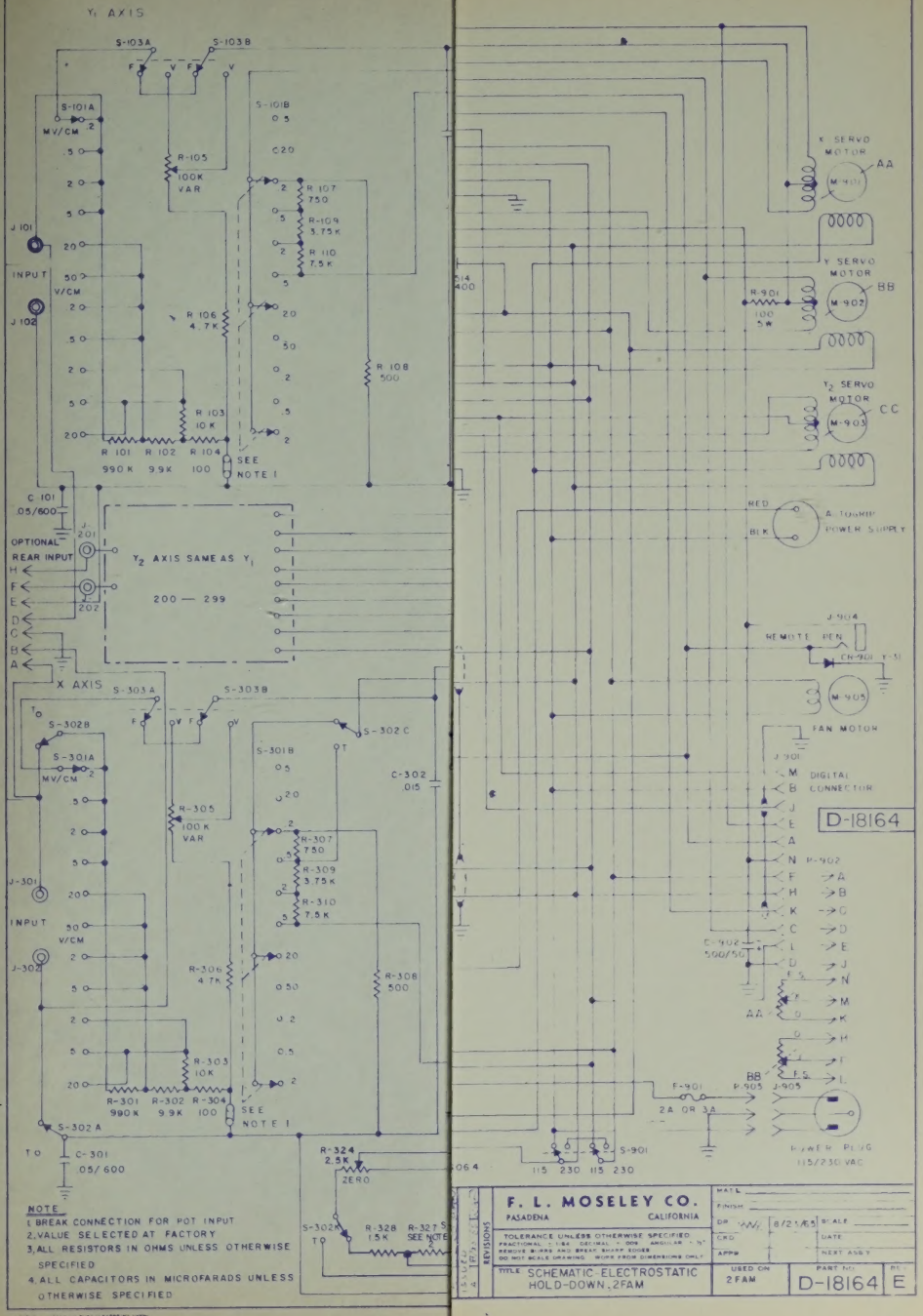
B/N	P/N	Description	Mfr. Designation
55	1410-0296	Bushing	Oilite

SCHEMATICS (attached D-16686 and D-18164)

Change R-901 to 50 ohm. Was 100 ohm
Change R-902 to 150 ohm. Was 50 ohm.
Change R-320 to 250K ohm. Was 100K ohm.
Change R-321 to 250K ohm. Was 100K ohm.

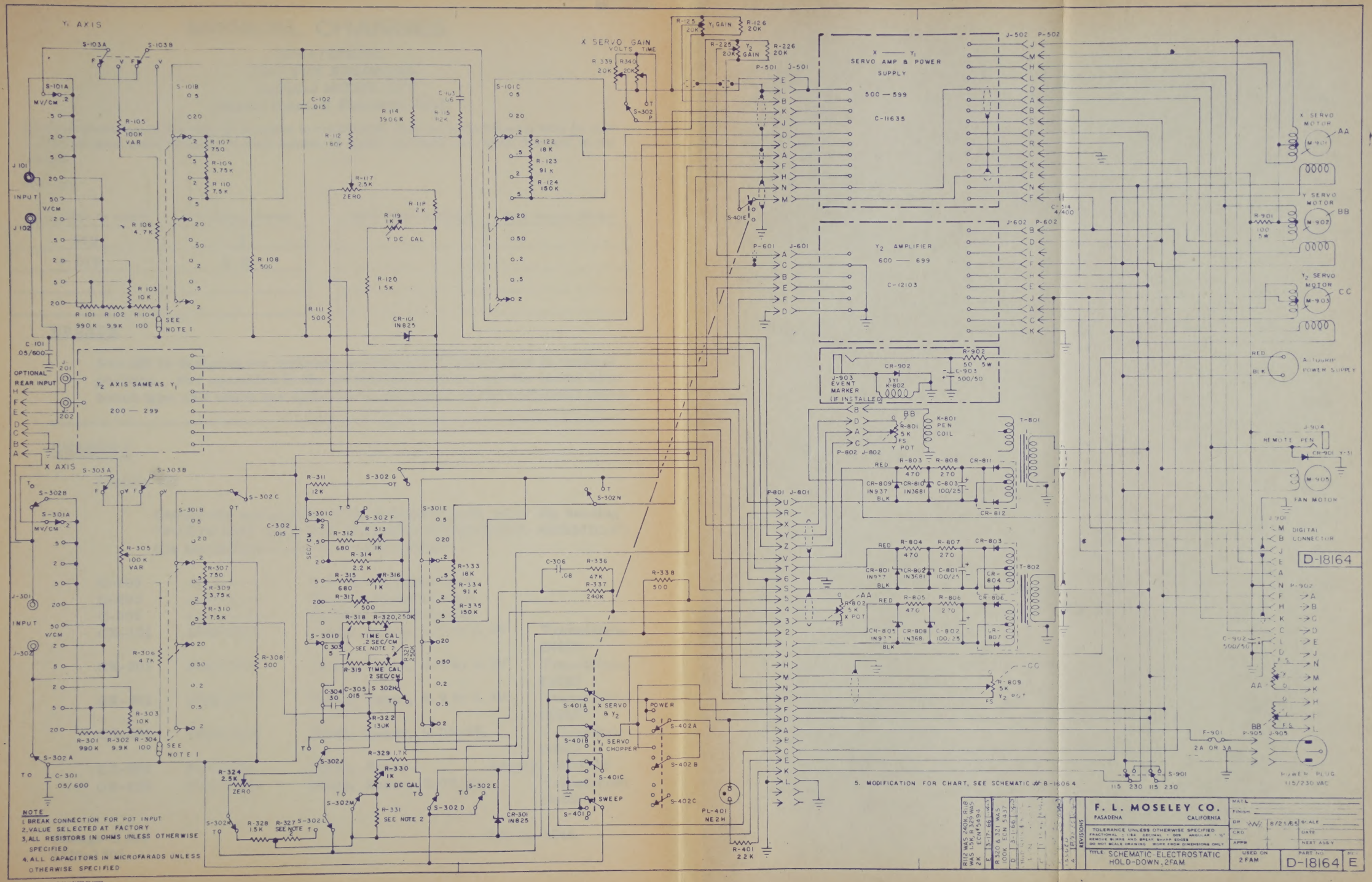



Y1 AXIS
X AXIS
X SERVO GAIN
VOLTS
TIME
X — Y1 SERVO AMP & POWER SUPPLY
500 — 599
C-18066
Y2 AMPLIFIER
600 — 699
C-18067
Y2 AXIS SAME AS Y1
200 — 299
OPTIONAL REAR INPUT
INPUT
V/DIV
MV/DIV
SEC/DIV
ZERO
Y DC CAL
X DC CAL
TIME CAL .5 SEC/DIV
SEE NOTE 1
SEE NOTE 2
X SERVO & Y2
Y1 SERVO & CHOPPER
SWEEP
POWER
X SERVO MOTOR
Y SERVO MOTOR
Y2 SERVO MOTOR
AUTOGRIP POWER SUPPLY
FAN MOTOR
DIGITAL CONNECTOR
REMOTE PEN
EVENT MARKER (IF INSTALLED)
PEN COIL
X POT
Y POT
Y2 POT
POWER PLUG 115/230 VAC
5. MODIFICATION FOR CHART, SEE SCHEMATIC # B-16064
NOTE
1. BREAK CONNECTION FOR POT INPUT
2. VALUE SELECTED AT FACTORY
3. ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
4. ALL CAPACITORS IN MICROFARADS UNLESS OTHERWISE SPECIFIED
F. L. MOSELEY CO.
PASADENA CALIFORNIA
TITLE: ELECTROSTATIC HOLD-DOWN SCHEMATIC 2FA
USED ON 2FA
PART NO D-16686 F
D-16686



NOTE
1. BREAK CONNECTION FOR POT INPUT
2. VALUE SELECTED AT FACTORY
3. ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
4. ALL CAPACITORS IN MICROFARADS UNLESS OTHERWISE SPECIFIED

REVISIONS	F. L. MOSELEY CO. PASADENA CALIFORNIA		MATL		
			FINISH		
			DR WW 8/21/65	SCALE	
	TOLERANCE UNLESS OTHERWISE SPECIFIED FRACTIONAL ± 1/64 DECIMAL ± .005 ANGULAR ± 1° REMOVE BURRS AND BREAK SHARP EDGES DO NOT SCALE DRAWING. WORK FROM DIMENSIONS ONLY		CKD	DATE	
			APPD	NEXT ASSY	
	TITLE SCHEMATIC ELECTROSTATIC HOLD-DOWN, 2FAM		USED ON 2FAM	PART NO. D-18164	REV. E


Y1 AXIS
X AXIS
Y2 AXIS SAME AS Y1
200 — 299
X SERVO GAIN
VOLTS
TIME
X — Y1 SERVO AMP & POWER SUPPLY
500 — 599
C-11635
Y2 AMPLIFIER
600 — 699
C-12103
J-903 EVENT MARKER (IF INSTALLED)
X SERVO MOTOR
Y SERVO MOTOR
Y2 SERVO MOTOR
A.C. TACH
POWER SUPPLY
REMOTE PEN
FAN MOTOR
DIGITAL CONNECTOR
POWER PLUG
115/230 VAC
OPTIONAL REAR INPUT
INPUT
V/CM
MV/CM
SEE NOTE 1
ZERO
X DC CAL
Y DC CAL
TIME CAL 2 SEC/CM
SEE NOTE 2
X SERVO & Y2 SERVO CHOPPER
POWER
SWEEP
K-801 PEN COIL
R-801 5K FS Y POT
R-802 5K FS X POT
R-809 5K Y2 POT
T-801
T-802
CR-812
F-901 2A OR 3A
S-901 115 230 115 230
D-18164
NOTE
1. BREAK CONNECTION FOR POT INPUT
2. VALUE SELECTED AT FACTORY
3. ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED
4. ALL CAPACITORS IN MICROFARADS UNLESS OTHERWISE SPECIFIED
5. MODIFICATION FOR CHART, SEE SCHEMATIC # B-16064
F. L. MOSELEY CO.
PASADENA CALIFORNIA
TITLE SCHEMATIC ELECTROSTATIC HOLD-DOWN, 2FAM
USED ON 2 FAM
PART NO. D-18164
REV. E